

CBO MEMORANDUM

A FRAMEWORK FOR PROJECTING
INTEREST RATE SPREADS
AND VOLATILITIES

January 2000

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NOTES

The figures in this memorandum indicate periods of recession by using shaded vertical bars. The bars extend from the peak to the trough of the recession.

Numbers in the text and tables may not add up to totals because of rounding.

PREFACE

Several recent bills before the Congress have proposed changing the benchmark used in setting interest rates for the federal student-loan program. Lenders participating in the program have urged the change to tie the rates they must pay to borrow funds in private-sector markets more closely to their returns on loans. The Higher Education Amendments of 1998 directed the Congressional Budget Office (CBO) and other organizations to study the issue and, in particular, to evaluate the spreads, or differences, between rates on three-month Treasury bills (the benchmark at that time) and the proposed alternatives, which include rates on commercial paper issued by financial companies and London interbank dollar deposits.

The study group that was formed asked CBO to develop a framework for projecting the future behavior of the alternative rates and the probability that they would exceed the interest rate threshold of the student-loan program. CBO prepared a technical paper in response to the request and presented its model at a study group meeting in August 1999. Since passage of the 1998 bill, the Congress has enacted a temporary change in the benchmark (in December 1999) to use rates on three-month commercial paper as the reference rate for student loans until 2003. CBO's projections will contribute to the debate about whether to make that change permanent.

This memorandum discusses CBO's model and presents illustrative projections of interest rate spreads and their volatilities, or movements, over the medium term (to 2009). Robert Arnold, Angelo Mascaro, and Matthew Salomon of CBO's Macroeconomic Analysis Division wrote the memorandum under the supervision of Robert Dennis and Kim Kowalewski. Nabeel Alsalam, Paul Cullinan, Deborah Kalcevic, Robin Seiler, Bruce Vavrichek, and Thomas Woodward, all of CBO, made valuable contributions at various stages of the analysis. The memorandum incorporates comments from members of the study group and other readers of the technical paper. In addition, the authors thank John Cunningham of Lehman Brothers Inc., Anthony Dolanski and Guido Van der Ven of the Student Loan Marketing Association, Randall Mariger of PricewaterhouseCoopers, and Calvin Schnure and Christopher Downing of the Board of Governors of the Federal Reserve for their useful suggestions.

David Arnold and Ezra Finkin provided research assistance. Leah Mazade edited the manuscript, and Chris Spoor proofread it. Verlinda Lewis Harris and Dorothy Kornegay prepared the memorandum for publication. Laurie Brown prepared the electronic versions for CBO's World Wide Web site (www.cbo.gov).

Questions about the memorandum may be directed to the Macroeconomic Analysis Division.

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January 2000

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CHAPTER I

SUMMARY AND INTRODUCTION

By law, interest rates on money borrowed through the federal student-loan program are tied to a reference, or benchmark, rate. For the past several years, the benchmark has been the rate on three-month Treasury bills. In 2003, the formula for setting interest rates in the program will begin using a different reference rate that is also based on Treasury securities. Lenders who participate in the programs have proposed changing the formula further: they advocate using a reference rate from private-sector markets to tie the interest they receive more closely to their costs for making the loans. In December 1999, the Congress enacted the Ticket to Work and Incentives Improvement Act (P.L. 106-170), which changes the benchmark for lender yields on student loans issued between January 2000 and June 2003 to the rate on commercial paper with a three-month maturity. (Commercial paper is defined here as short-term debt issued by financial companies.) The change is a temporary one, covering only the period noted.

In estimating the cost of the various proposals for changing the benchmark, the Congressional Budget Office (CBO) developed a framework, or model, for projecting the proposed alternative rates and their volatilities (in general, the tendency of the rates to change over time). With the change in the benchmark, CBO will now use that framework to project commercial paper rates for its economic outlook and budget baseline. Projections from the model will also be used as the Congress considers permanent changes to the benchmark in the student-loan program. This memorandum discusses CBO's framework and its underpinnings and presents illustrative results for rates on various short-term financial instruments.

THE FEDERAL STUDENT-LOAN PROGRAM

The student-loan program covers two types of loans: direct loans from the federal government and loans issued by private lenders on which the government guarantees repayment. All student loans carry variable interest rates that are adjusted annually according to formulas specified in law. However, the rates that borrowers must pay on the loans are limited by statutory caps, and those caps have important implications for the federal budget. In the case of direct loans, the caps limit repayments to the government, thus raising the overall federal cost of the loans. For guaranteed loans, the government makes so-called special-allowance payments to private lenders to cover the difference whenever the formula-based interest rates rise above the caps. Estimates of the cost of the student-loan program must therefore allow for the possibility that interest rates will exceed the caps.

Recent legislation has made several changes in the formulas for interest rates on student loans. For loans issued between July 1, 1998, and December 31, 1999, student borrowers taking new loans pay an annually adjusted rate equal to the rate on three-month Treasury bills plus an additional premium based on the borrower's status: while the borrower is in school or in a grace, or deferment, period, the premium is 170 basis points (a basis point is one-hundredth of a percentage point); otherwise, the add-on is 230 basis points. However, the rate that the student borrower pays is capped at 8.25 percent. (Terms for parent borrowers are somewhat less attractive.) The interest rates paid to lenders are based on the quarterly average of three-month Treasury bill rates plus 280 basis points when the loans are being repaid and 220 basis points at other times.

As of January 1, 2000, the rate on three-month commercial paper will become the reference rate for lender yields. (In general, the yield is the expected return on the loans.) For student loans, the yield will equal the interest rate on three-month commercial paper plus 174 basis points while the borrower is in school or in the grace period and 234 basis points while the borrower is repaying the loan. Lender yields on parent and consolidated loans will equal the rate on three-month commercial paper plus 264 basis points. Under current law, however, the basis for the interest rate formula is slated to change once again in 2003 to Treasury securities whose maturity is comparable with the maturity of student loans. The Treasury and CBO have both interpreted that reference rate as the average for long-term Treasury securities (including 10-year Treasury notes as well as bonds with even longer maturities).

CHANGING THE INTEREST RATE FORMULAS

Before enactment of P.L. 106-170 in December 1999, tying lender yields to Treasury benchmarks had raised concerns among lenders and spurred proposals for changing the rate formulas. Private financial institutions making loans through the federal student-loan program wanted Treasury interest rates to be replaced permanently with private-market rates as the new reference. Lenders argued that private-market rates determined their loan costs and that they risked losing money if the interest rates at which they borrowed funds for student loans did not move in tandem with the Treasury's rates.¹ Lenders were also concerned that projected federal surpluses might shrink the market for Treasury bills (which are sold to finance government debt) by enough to make the bills less representative of overall market rates.

1. For further discussion of the funding risk, see Congressional Budget Office, "Letter to the Honorable Pete V. Domenici Regarding the Profitability of Federally Guaranteed Student Loans," March 30, 1998 (available at <http://www.cbo.gov/otherdoc.html>).

Generally speaking, lenders argue that their costs of funds for student loans are closely tied to private-sector markets for short-term securities—particularly commercial paper issued by financial firms and London interbank dollar deposits. (The interest rate on those deposits is known as LIBOR—the London interbank offer rate.) The market for commercial paper is now much larger than the market for Treasury bills and is likely to continue to grow. Similarly, LIBOR plays a role domestically and internationally as a reference rate for many private-market loan instruments, and that role is not likely to diminish.

Using such alternative rates in interest formulas for the student-loan program may reduce the risk that lenders face, but other factors also require consideration. The government has used three-month Treasury bills as a benchmark for the student-loan program because their interest rate is widely regarded as a standard measure of a risk-free rate—that is, free of the risk of default. Another reason for their use is that CBO and the Administration already project future Treasury bill rates as part of the federal budget process. Of primary importance is what happens to federal costs for the program if one of the alternative rates is used. In estimating such costs, CBO must take into account not just the expected differences, or spreads, between Treasury bill rates and the alternatives but also the rates' differing volatilities.² The alternative rates are generally more volatile than the rates mandated for loans after June 2003. As a result, the probability increases after that date that interest rates will from time to time exceed the caps. Assessing those probabilities and the potential need for special-allowance payments requires analysts to both understand the factors underlying movements of rates in the past and be able to project future rates and their volatilities.

Over the past three decades, interest rates and interest rate spreads have been at times volatile and at times relatively stable. In the 1970s and 1980s, a variety of shocks buffeted the rates, producing relatively large ups and downs. (Such events include the end of the Bretton Woods system of fixed exchange rates and the oil price hikes occurring in the mid- and late 1970s.) Important changes in the U.S. financial system—for example, increased diversity in the intermediation between savers and borrowers and wider dispersion of risk bearing—may help prevent such shocks from battering rates in the future. In the past decade, in fact, markets have generally been calmer, and relatively few big jolts have moved interest rates and spreads.

To estimate the cost of the student-loan program, CBO constructed a general statistical model (that is, a system of interrelated equations) that can accommodate the kind of changes noted above. The two-step model, which projects different benchmark interest rates and their volatilities, takes into account the diminished movement of rates in the 1990s and even finds some systematic reasons for that

2. See the appendix for a more detailed description of how spreads are calculated.

change in the relatively low inflation and stable monetary policy that the United States has enjoyed since the mid-1980s. (Of course, the projections also allow for the possibility that inflation will climb.) For technical reasons, CBO chose to project the spreads between rates on Treasury bills and on the alternative instruments rather than the level of those rates. In discussing its model and the illustrative projections, CBO uses “rates” and “spreads” interchangeably to refer to the rates’ future behavior.

The model’s results show that with one exception, spreads between the alternative rates and rates on three-month Treasury bills are narrow compared with past average spreads. (For the most part, the spreads discussed in this paper are measured against the three-month Treasury bill.) The spreads’ general narrowing in CBO’s estimates stems mainly from the favorable economic conditions that CBO is projecting for the next several years. The exception is the spread for three-month commercial paper. In the past, that spread has been slightly smaller than the spread for one-month commercial paper. CBO’s model estimates that it will be slightly wider than the one-month spread over the 1999-2009 projection period.

CHAPTER II

BACKGROUND ON INTEREST RATES FOR

SHORT-TERM FINANCIAL INSTRUMENTS

Several key questions offer a framework for examining the short-term financial instruments that could be used as benchmarks in interest rate formulas for the federal student-loan program. What are the characteristics of the instruments, and how are they similar to or different from each other? What determines the expected return on the instruments and, in turn, the differences, or spreads, between them? Why have those spreads narrowed in recent years and become less volatile? The answers to those questions bear on any decision to permanently replace Treasury securities with one of the alternative interest rates as a benchmark for lender yields in the student-loan program.

WHAT ARE THE INSTRUMENTS' MAJOR CHARACTERISTICS?

Treasury bills, commercial paper, and London interbank deposits of U.S. dollars are all part of the money market—that segment of the capital market encompassing short-term (one year or less) financial instruments. As noted earlier, markets for commercial paper and for London interbank deposits have been growing in recent years. That expansion as well as other characteristics of those instruments may strengthen the case for using their rates in the student-loan program.

Treasury Bills

Treasury bills, which the federal government issues (offers for sale) weekly to finance its deficits, are distinguished from other money market instruments by two features. First, they are perceived as “safe” investments, free from default, or credit, risk. Second, they have a high degree of liquidity—they can easily be sold for cash because they are readily accepted by investors in the United States and abroad, both in turbulent times and during normal economic and financial conditions.

Treasury bills are issued in denominations of up to \$1 million with maturities of three months, six months, or one year. The Federal Reserve typically holds large amounts—recently, about \$200 billion. It acquires and sells Treasury bills through dealers in government securities in the course of conducting the nation’s monetary policy. Government security dealers are part of the secondary market for bills, intermediating between the Treasury and other holders, which include foreign govern-

TABLE 1. OUTSTANDING DOLLAR VOLUME IN MARKETS FOR SHORT-TERM FINANCIAL INSTRUMENTS (In billions)

Instrument	1970	1980	1990	1997	1998
Treasury Bills	76	200	482	715	691
Commercial Paper ^a	33	164	610	958	1,161
London Interbank Dollar Deposits	48	195	397	487	494

SOURCES: Congressional Budget Office using data from *Economic Report of the President* (1999); Board of Governors of the Federal Reserve, *Flow of Funds Accounts of the United States* (various years); Bank for International Settlements, *Forty-Fifth Annual Report* (1970); and Bank of England, *Monetary & Banking Statistics* (1980, 1990, 1997, and 1998).

a. Short-term debt issued by both financial and nonfinancial companies.

ments and central banks, money market mutual funds, financial institutions, state and local governments, and individuals.

Once the largest of the three markets as measured by outstanding dollar volume, the market for Treasury bills now occupies second place, after the market for commercial paper (see Table 1). If federal surpluses persist, it could fall behind the London interbank dollar market as well over the next decade.

Commercial Paper

Dominating the money market since the 1980s, commercial paper is short-term, unsecured debt that firms use to finance immediate-cash needs. The securities are issued in maturities of up to nine months and in amounts of as much as several million dollars.¹ Issuers of commercial paper fall into two categories: financial companies and nonfinancial companies. Financial-company issuers, which account for about 80 percent of the commercial paper now outstanding, are mostly funding corporations of nonfinancial firms (for example, General Motors), finance companies, issuers of asset-backed securities (discussed below), funding subsidiaries of banks, and analogous foreign entities (see Table 2). (Because nonfinancial-company issuers make up such a small percentage of the market, they are not discussed here.)

1. Maturities of more than nine months would trigger registration requirements of the Securities and Exchange Commission.

TABLE 2. DISTRIBUTION OF COMMERCIAL PAPER ISSUERS (In percent)

	1960	1970	1980	1990	1998
Financial Issuers					
Funding corporations	0	0	10	25	20
Finance companies	83	71	39	29	20
Asset-backed securitizers ^a	0	0	0	6	33
Other ^b	<u>0</u>	<u>7</u>	<u>22</u>	<u>6</u>	<u>4</u>
Total	83	78	71	66	77
Nonfinancial Issuers	17	22	23	21	17
Foreign Issuers in the United States ^c	0	0	6	14	6

SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve.

a. Companies that issue commercial paper (short-term debt) backed by collateral—for example, credit card balances or automobile loans.

b. Includes commercial banks and real estate investment trusts.

c. Includes financial and nonfinancial issuers.

Commercial paper allows large firms to obtain cash directly from the money market instead of borrowing it from banks. Firms that are not large enough to sell their own commercial paper directly can still use the commercial paper market through intermediary dealers who in turn line up buyers.

Holders of commercial paper make up a broad range of investors. They include money market mutual funds (today, the predominant group of holders), retirement-related entities (trusts, public and private pension funds, and insurance companies), banks, and corporations (see Table 3). Foreign entities such as governments and central banks also hold commercial paper to keep their dollar holdings invested and earn a market rate of return.

Factors affecting both demand and supply have propelled the recent growth in the commercial paper market. Investors' increasing appetite for money market mutual funds has fueled demand for commercial paper, with the funds purchasing it as part of their investment portfolios. The explosive growth during the 1990s in information-related technologies has played a key role in that trend by facilitating transactions.

TABLE 3. DISTRIBUTION OF COMMERCIAL PAPER HOLDERS (In percent)

	1960	1970	1980	1990	1998
Households	39	31	23	10	5
State and Local Governments	0	0	0	1	8
Foreign Holders	20	11	6	2	10
Life Insurance Companies	4	5	6	7	6
Money Market and Other Mutual Funds	3	3	21	38	41
Funding Corporations	3	3	2	21	9
Other ^a	31	46	42	20	20

SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve.

NOTES: Commercial paper is short-term debt issued by both financial and nonfinancial companies.

The Federal Reserve data also cover bankers' acceptances (commercial instruments that are issued by banks and that closely resemble commercial paper).

- a. Includes nonfinancial corporate businesses, monetary authorities, commercial banks, savings institutions, credit unions, bank personal trusts and estates, private pension funds, state and local government retirement funds, government-sponsored enterprises, and brokers and dealers.

Financial innovations have been a similar linchpin in the growth of supply in the commercial paper market.² One example is the increase in securitization—selling debt securities to investors and using groups of relatively homogeneous loans as collateral. Thus, financial companies may issue asset-backed commercial paper, using the money they expect from such receivables as credit card balances or automobile loans as collateral.³ Another example of innovation is the growth of interest rate swaps. A simple case might involve a company that owed a debt with a fixed rate of interest and that wished to convert it into debt with a floating rate. A sequence of commercial paper transactions is often used to make the switch.⁴

2. Further discussion of the role of financial innovation and information technologies can be found in Dusan Stojanovic and Mark D. Vaughan, "The Commercial Paper Market: Who's Minding the Shop," *Regional Economist*, Federal Reserve Bank of St. Louis (April 1998).
3. See Barbara Kavanagh, Thomas Boemio, and Gerald Edwards Jr., "Asset-Backed Commercial Paper Programs," *Federal Reserve Bulletin*, vol. 78, no. 2 (February 1992), pp. 107-116.
4. Marcia Stigum describes swaps and other innovations in *The Money Market*, 3rd ed. (Homewood, Ill.: Business One Irwin, 1990).

London Interbank Dollar Deposits

London interbank deposits of U.S. dollars are loaned to and borrowed by international banks in London. Such deposits come originally from other financial institutions, large corporations, individuals, and governments. Deposits are made in large amounts at fixed maturities (typically ranging from overnight to 12 months). The lending and borrowing that is the defining characteristic of the interbank market mostly reflects individual banks trying to manage cash flows and risk in their domestic and international operations.

Interest rates on London interbank dollar deposits are quoted on an offer-and-bid basis. The rate asked by the lender is the offer rate—LIBOR, for London interbank offer rate. The rate on funds wanted by the borrower is the bid rate—LIBID, for London interbank bid rate. The British Bankers' Association compiles a measure of LIBOR from a sample of market participants that changes as conditions warrant (see Table 4 for the 1999 panel of contributing banks).

As noted earlier, LIBOR is used as a reference rate for loans made by private financial institutions operating both internationally and domestically. Its role stems from London's global prominence as a financial center and the U.S. dollar's preeminence in financial transactions.⁵ Further enhancing its importance is the proliferation of financial innovations (such as interest rate swaps) that require a reference rate acceptable among borrowers and lenders throughout the financial world.

The London interbank dollar market is about half the size of the commercial paper market and is expanding more slowly. Since 1980, the market has grown about 5.2 percent annually compared with annual growth in the commercial paper market of 10.9 percent. How the launching of the Euro currency and other aspects of monetary unification in Europe will affect the future growth of the London interbank dollar market is not known.

WHAT DETERMINES THE INSTRUMENTS' YIELDS AND SPREADS?

Spreads between the interest rates on Treasury bills, commercial paper, and London interbank deposits depend on the comparative risk of investing in those instruments and the return, or yield, expected from them. (Specifically, yield is the average annual rate of return on a security over the period it is held.) The characteristics of

5. See Stephen Valdez, *An Introduction to Western Financial Markets* (London: MacMillan Press Ltd., 1993).

TABLE 4. BANKS SUPPLYING INTEREST RATES THAT WERE USED TO CONSTRUCT LIBOR IN 1999

Country	Bank
United States	Bank of America Chase Manhattan Bank Citibank
United Kingdom	Abbey National Barclays Bank HSBC Lloyds Bank National Westminster Bank Royal Bank of Scotland
Japan	Bank of Tokyo Mitsubishi Fuji Bank Norinchukin Bank
Switzerland	Credit Suisse-First Boston Union Bank of Switzerland
Germany	Deutsche Bank Westdeutsche Bank

SOURCE: Congressional Budget Office using data from the British Bankers' Association.

NOTE: The London interbank offer rate, or LIBOR, is the interest rate on London interbank dollar deposits.

the participants that issue, market, and hold the instruments and the institutional and legal arrangements governing them and the markets all help to determine risks and returns. Generally, the gaps between interest rates widen when monetary policy becomes tighter (the cost of credit rises) or more volatile, or when inflation or expectations of inflation increase. On those occasions, differences in the riskiness of the three instruments intensify, and the interest rate spreads correspondingly widen.

Treasury Bills

Interest rates on Treasury bills are usually the lowest of the three short-term rates. They are influenced mainly by expectations about inflation, by overall conditions of demand and supply in the markets for credit and goods, and by perceptions about risk and uncertainty. The interest paid on Treasury bills includes an inflation premium—compensation for any expected loss of purchasing power. At the same time, however, Treasury bill rates probably have only a small or no liquidity premium—compensation for holding bills instead of cash—because holders have a ready

market in which to sell the bills, should they need cash before the maturity date. (For large transactions, the bills themselves could be used as payment.) Also missing from the interest rate paid on Treasury bills is a credit-risk premium—compensation to offset the chance that the issuer might default—because of the superior credit standing of the federal government. In fact, during turbulent financial times, investors' increased desire for default-free assets tends to produce particularly low interest rates on Treasury bills compared with money market instruments issued by the private sector.

Commercial Paper

Several features of commercial paper lead to differences between its interest rates and those paid on Treasury bills (see Table 5). The rates paid on money invested in commercial paper are generally higher, in part because they include a credit-risk premium. The premium is necessary because holders of commercial paper assume that its issuers could encounter unexpected financial difficulties that might jeopardize their solvency or, at the least, their ability to honor their obligations on time.

TABLE 5. AVERAGE INTEREST RATE SPREADS FOR COMMERCIAL PAPER AND LONDON INTERBANK DOLLAR DEPOSITS
(In percentage points, by maturity)

Spread ^a	1960-1998	1971-1998	1980-1998	1985-1998
Commercial Paper ^b				
One month	0.42	0.45	0.46	0.41
Three months	n.a.	0.41	0.37	0.43
London Interbank Dollar Deposits ^c				
One month	1.03	1.01	0.88	0.60
Three months	n.a.	1.19	1.00	0.69

SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve and the London *Financial Times*.

NOTE: n.a. = not available.

- a. Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.
- b. Short-term debt issued by financial companies.
- c. The rate used is LIBOR—the London interbank offer rate.

Commercial paper is also less liquid than Treasury bills—paper holders might not readily find a buyer, should they wish to sell before their holdings reach maturity. At the same time, however, purchasers normally expect to hold commercial paper until it matures. As a result, analysts consider that in ordinary financial circumstances, commercial paper's lesser liquidity relative to Treasury bills has little effect on its interest rates.⁶

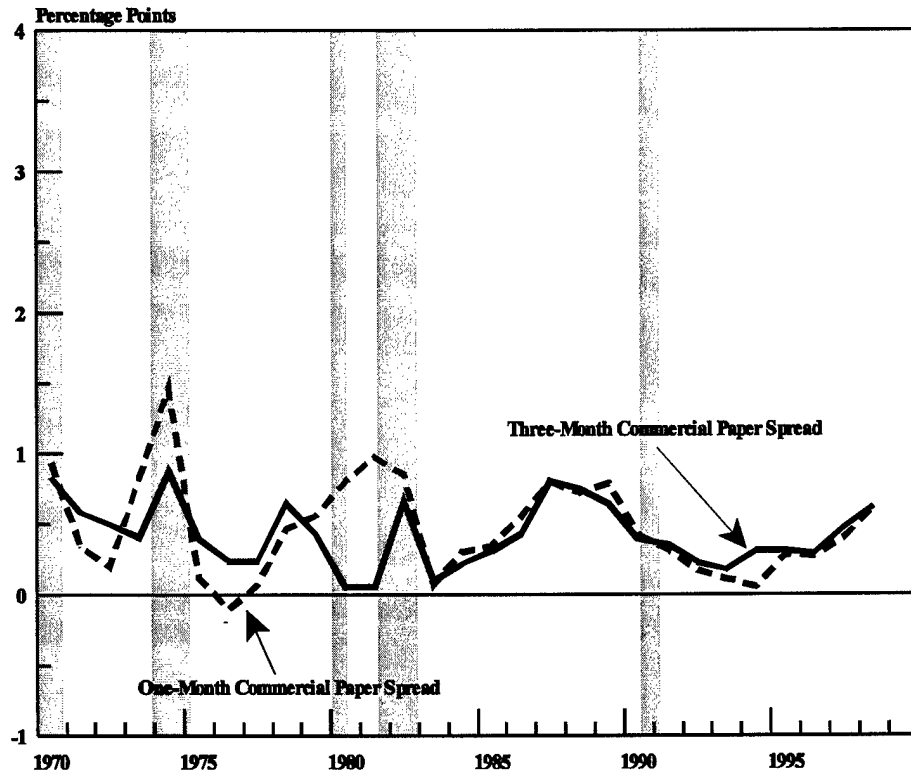
Credit and liquidity premiums vary with the economy's cyclical position, including the cyclical stance of monetary policy. As a result, spreads between commercial paper and Treasury bill rates vary in a similar fashion, shrinking during periods of economic expansion, when concerns about credit risk recede, and at times expanding abruptly during economic downturns, when financial difficulties surface (see Figure 1). Similarly, the spread widens when the Federal Reserve tightens monetary policy by trimming the money supply, thus reducing liquidity in the money market. Tighter monetary policy not only causes liquidity premiums to rise but also may elicit investors' fears about credit risk.

When financial markets move from normal to turbulent periods, credit and liquidity premiums both tend to increase substantially as potential purchasers of commercial paper become more averse to risk and seek a "safe haven" in instruments such as Treasury bills. In recent years, several episodes of turbulence or shocks have significantly affected the spreads shown in Figures 1 through 5. Those events include:

- o The end of the system of fixed exchange rates, which was established in 1944 at Bretton Woods, New Hampshire, and collapsed in mid-1971;
- o The dramatic hikes in petroleum prices in 1973 and 1979, the first accompanied by insolvencies among banks and industrial corporations and the second by loan defaults among developing countries;
- o The dollar crisis of 1978 that compelled the United States to borrow \$30 billion from Japan, Germany, and Switzerland to restore international confidence in the exchange value of the dollar; and
- o The financial turmoil of 1998 comprising the collapse of many Asian economies, default by the government of Russia, and failure of the hedge

6. For further discussion of the liquidity premium, see Frank Fabozzi, "Private Money Market Instruments," in Frank Fabozzi and T. Dossa Fabozzi, eds., *The Handbook of Fixed Income Securities*, 4th ed. (New York: Irwin Professional Publishing, 1995).

FIGURE 1. INTEREST RATE SPREADS FOR ONE-MONTH AND
THREE-MONTH COMMERCIAL PAPER



SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve.

NOTES: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

Commercial paper is defined here as short-term debt issued by financial companies.

fund Long-Term Capital Management (despite the Nobel-laureate economists and financial-industry notables among its directors and executives).

London Interbank Dollar Deposits

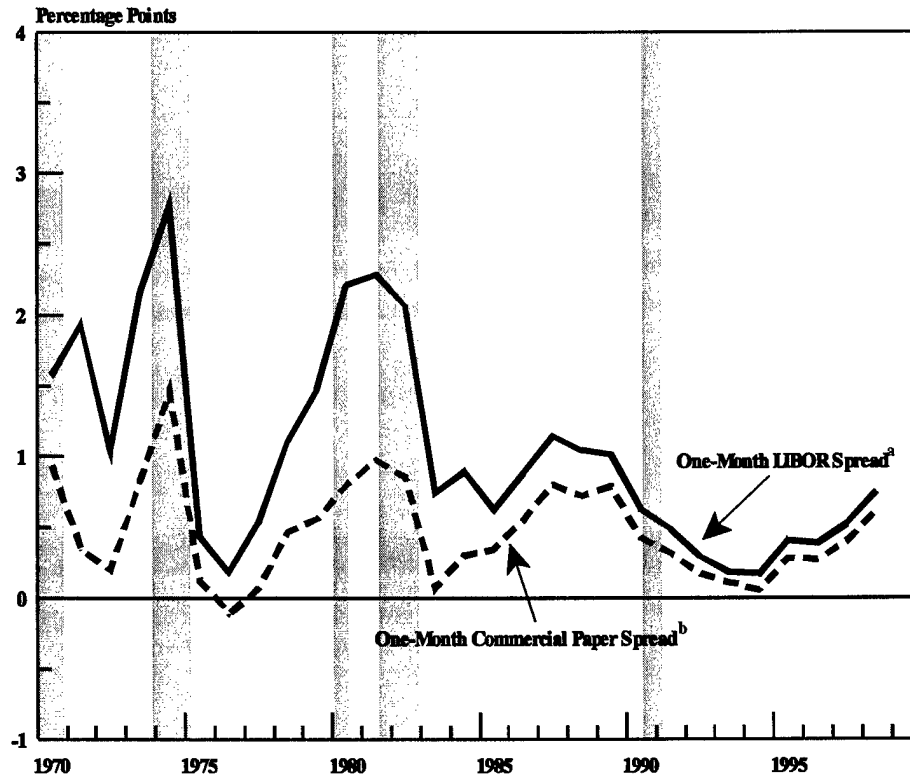
Spreads between LIBOR and rates on three-month Treasury bills are generally larger than those between commercial paper and Treasury bills, although the gaps have narrowed over the past few years (see Figures 2 and 3). Interest rates on London interbank dollar deposits include liquidity and credit-risk premiums similar to those embedded in commercial paper rates. As a result, LIBOR should also vary with overall interest rates, inflation, and monetary policy. But the interbank nature of LIBOR leads to higher liquidity and credit-risk premiums for interbank deposits than for commercial paper.

Three factors apparently account for the larger LIBOR spreads, although no systematic analysis has quantified the factors' relative importance. First, the London interbank market for dollar deposits is closely linked to the U.S. interbank market for federal funds—the reserves that banks have on deposit at the Federal Reserve and that they buy and sell among themselves (see Figure 4). For example, a U.S. bank is required to hold a certain amount of cash in reserve in proportion to its deposits. It can meet that requirement by borrowing federal funds from another bank in the United States or by borrowing Eurodollars from a bank in London. London interbank dollars, federal funds, and commercial paper all trade on an unsecured basis—no collateral is required—and that feature leads to added credit-risk premiums, relative to the rate on Treasury bills. Compared with issuers of commercial paper, especially nonbank financial institutions such as finance companies, banks typically operate with much higher leverage (higher levels of debt to equity), which might also lead to higher credit-risk premiums on interbank rates.⁷

Risk related to a borrower's nation may be a second reason for the larger LIBOR/Treasury bill spreads. A bank's home country might itself be a source of risk because of its economic and financial circumstances, its regulatory policies for financial institutions, or its political situation, any or all of which could cause the bank to be willing to pay a premium for the funds it borrows through the interbank market. That premium could influence the LIBOR measure since LIBOR is compiled by averaging rates from banks with different home countries. The size of the premium can be expected to vary over time.

7. At the same time, however, a participant in the London interbank market has access to its home country's central bank, which might help reduce the premium if such access limits the bank's risk of default.

FIGURE 2. INTEREST RATE SPREADS FOR ONE-MONTH LONDON INTERBANK DOLLAR DEPOSITS AND ONE-MONTH COMMERCIAL PAPER



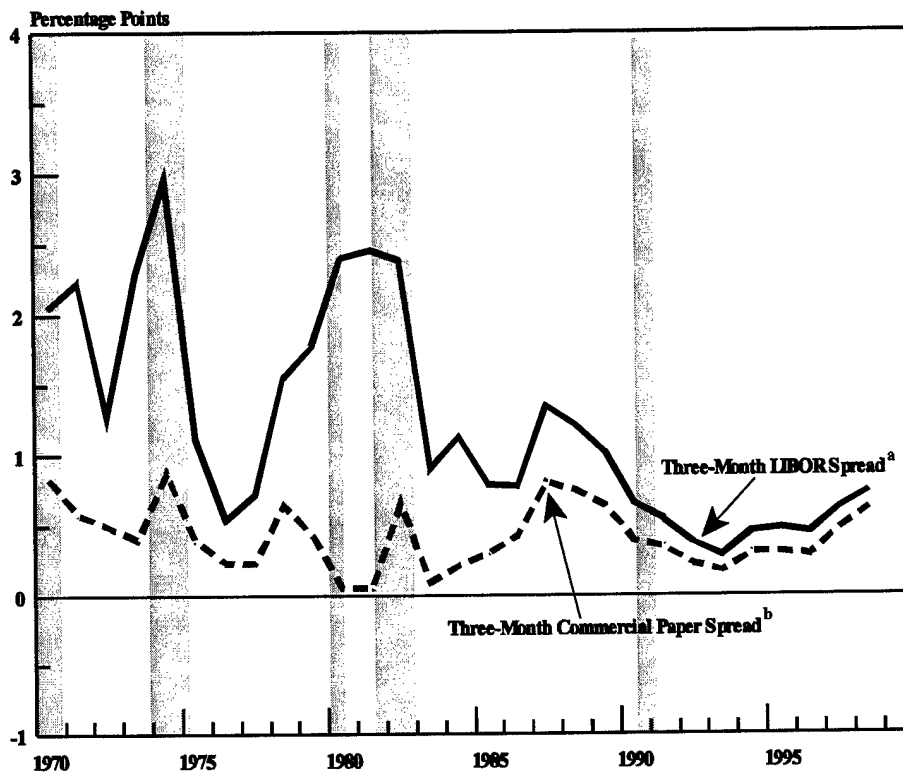
SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve and the British Bankers' Association.

NOTE: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

a. The rate on London interbank dollar deposits is known as LIBOR—the London interbank offer rate.

b. Commercial paper is defined here as short-term debt issued by financial companies.

FIGURE 3. INTEREST RATE SPREADS FOR THREE-MONTH LONDON INTERBANK DOLLAR DEPOSITS AND THREE-MONTH COMMERCIAL PAPER



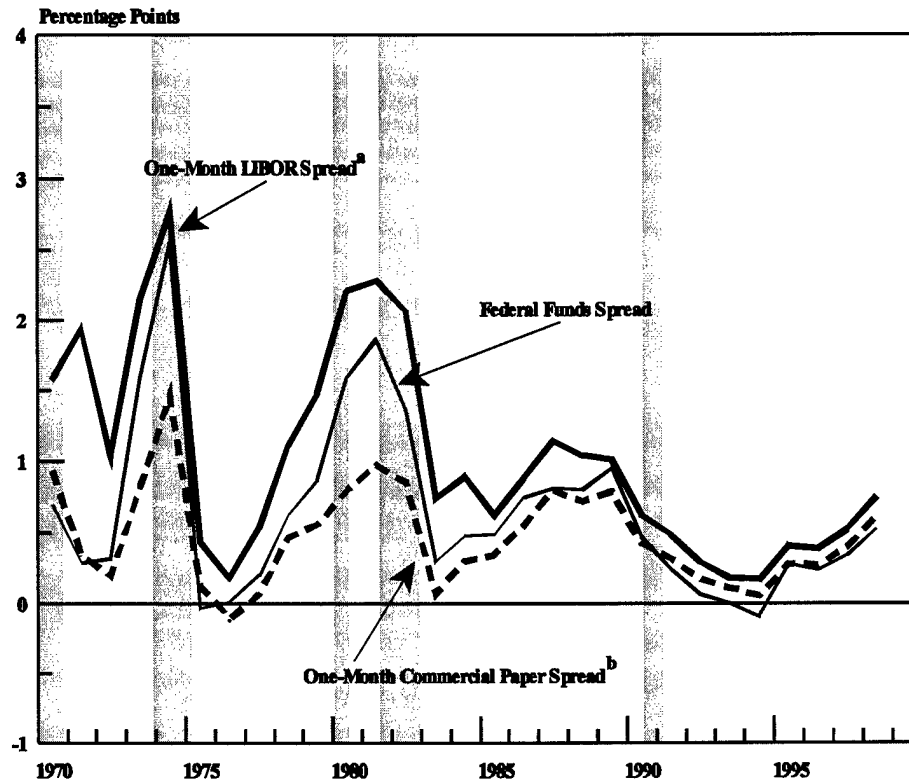
SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve and the British Bankers' Association.

NOTE: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

a. The rate on London interbank dollar deposits is known as LIBOR—the London interbank offer rate.

b. Commercial paper is defined here as short-term debt issued by financial companies.

FIGURE 4. INTEREST RATE SPREADS FOR FEDERAL FUNDS, ONE-MONTH LONDON INTERBANK DOLLAR DEPOSITS, AND ONE-MONTH COMMERCIAL PAPER



SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve and the British Bankers' Association.

NOTE: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

a. The rate on London interbank dollar deposits is known as LIBOR—the London interbank offer rate.

b. Commercial paper is defined here as short-term debt issued by financial companies.

Banks' reserve requirements and deposit insurance premiums are a third factor that could drive a wedge between LIBOR and interest rates on commercial paper. However, research has been unable to determine with statistical precision the strength of that factor's effect.⁸

WHY HAVE SPREADS NARROWED IN RECENT YEARS?

In the mid-1980s, LIBOR/Treasury bill spreads started moving closer to commercial paper/Treasury bill spreads, resulting in a narrow gap throughout the 1990s between LIBOR and commercial paper. Since the early 1990s, LIBOR/commercial paper spreads have averaged about 23 basis points for three-month maturities and about 15 basis points for one-month maturities (see Figure 5).

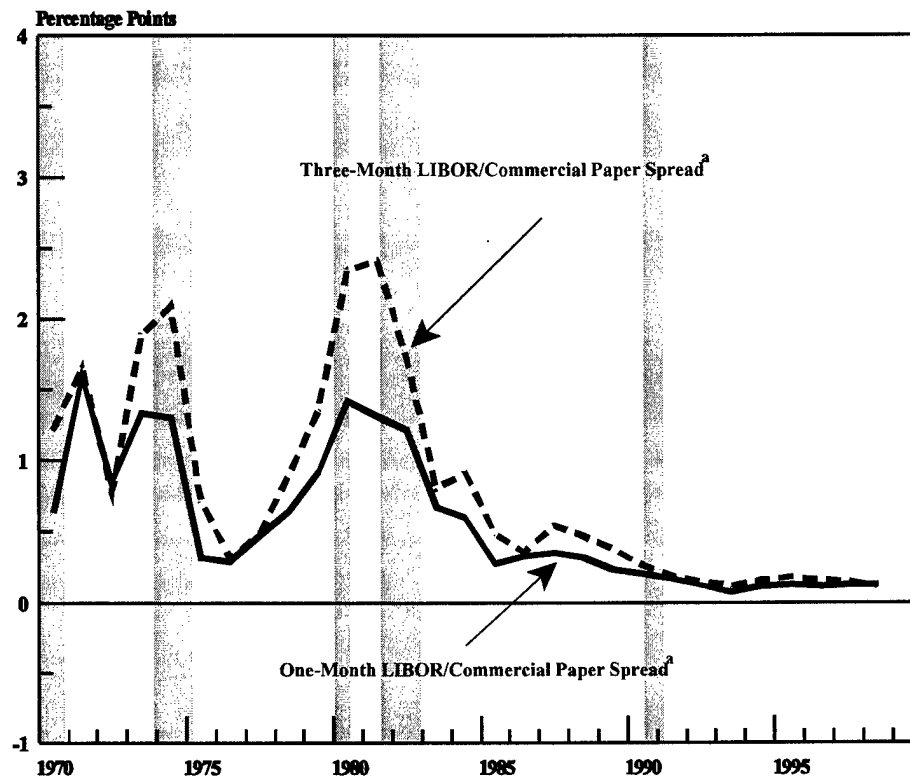
Favorable circumstances in the money markets throughout the 1990s probably explain much of the behavior of LIBOR/commercial paper spreads. Monetary policy has become progressively more stable: the federal funds rate has become less volatile compared with past decades, and the Federal Reserve has provided more information so that market participants can anticipate changes in policy. (Whether the reduced volatility in the federal funds rate stems mostly from improved monetary policy or is a by-product of a less volatile economic environment is an open question that is not addressed here.) With less volatility, overall liquidity and credit-risk premiums may have dropped, thus narrowing the differences between such premiums on LIBOR and commercial paper rates. Another contribution to smaller LIBOR/commercial paper gaps may be low overall interest rates, which have also benefited the money markets and helped shrink the spreads between most short-term rates.

The integration of domestic and international financial markets has probably also helped whittle down spreads between LIBOR and commercial paper rates. Technological advances in computers and telecommunications enable issuers and holders of securities to shift back and forth between the Eurodollar market, the commercial paper market, and other domestic and foreign money and capital markets, with the result that spreads have contracted relative to their past levels. Advances in financing methods have also played a role. For example, the expanding market for interest rate swaps has tightened the connections between commercial paper and London interbank markets.

Yet another factor in the narrowing of LIBOR/commercial paper spreads could be the lapse of some of the regulatory influences cited earlier. For example, reserve requirements imposed by the Federal Reserve on funds borrowed abroad were elimi-

8. See Richard C. Marston, *International Financial Integration: A Study of Interest Differentials Between the Major Industrial Countries* (Cambridge: Cambridge University Press, 1995).

FIGURE 5. INTEREST RATE SPREADS BETWEEN ONE-MONTH AND THREE-MONTH LONDON INTERBANK DOLLAR DEPOSITS AND ONE-MONTH AND THREE-MONTH COMMERCIAL PAPER



SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve and the British Bankers' Association.

NOTE: Spreads (the differences between rates) are computed on a bond-equivalent basis.

a. The rate on London interbank dollar deposits is known as LIBOR—the London interbank offer rate. Commercial paper is defined here as short-term debt issued by financial companies.

nated in 1990. Further shrinkage may have come from falling insurance premiums on bank deposits: since the mid-1990s, insurance funds administered by the Federal Deposit Insurance Corporation have been replenished, and banks have increased their capital. No doubt other reasons could be found as well.

WHAT DETERMINES THE SPREADS' VOLATILITIES?

Strikingly, interest rate spreads have become less volatile as they have narrowed. Most of the decline in volatility has occurred since the mid-1980s (see Table 6 and Figure 6).

What has caused that drop? Developments in the financial markets are unlikely to be the whole answer. (In fact, events such as the Asian financial turmoil and Russian debt default have had the opposite effect.) The recent sharp decline in inflation could be a factor by helping to improve the overall investment climate in financial markets. The drop in inflation coincided with the decline in volatility, just as the surges in inflation in the 1970s and early 1980s coincided with jumps in volatility (see Figure 7).

Inflation affects interest rates through several channels. Sustained low inflation helps financial markets work more efficiently and leads businesses to focus on improving productivity and efficiency. Eventually, profitability rises, balance sheets are strengthened, and people attach less risk to investing for the long term. All of those developments ultimately contribute to less volatility in returns on assets and in interest rates.⁹ Consequently, when the economy receives an unanticipated shock, such as those occurring in 1998 in Asia and elsewhere, companies that issue commercial paper and banks that borrow in the London interbank market are not perceived to be in jeopardy. Because interest rates associated with those markets do not react as adversely as they might otherwise, volatility is less.

Factors such as inflation and the economic shocks discussed above are all part of the model CBO has developed for projecting alternative interest rates and their volatilities. Such projections anchor CBO's estimates of the cost of proposals for changing the benchmark used in the student-loan program.

9. For additional discussion, see the statement of Alan Greenspan, Chairman, Board of Governors of the Federal Reserve, before the Senate Committee on Banking, Housing, and Urban Affairs, July 18, 1996 (available at <http://www.bog.frb.fed.us/boarddocs/hh/1996/july/testimony.htm>).

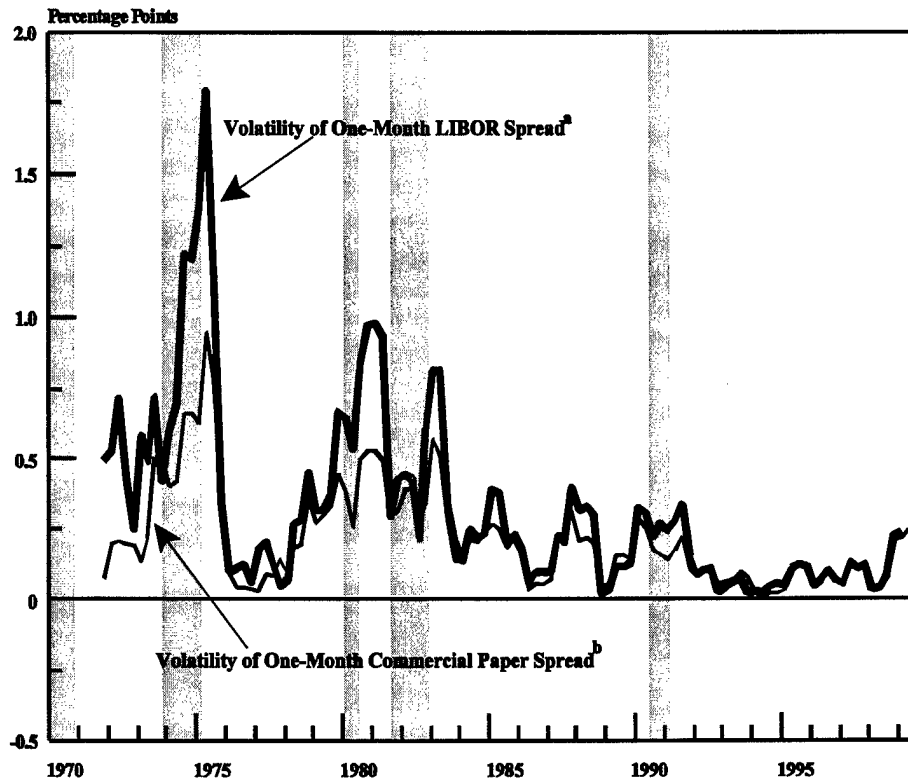
TABLE 6. VOLATILITY AND AVERAGE SIZE OF INTEREST RATE SPREADS FOR COMMERCIAL PAPER AND LONDON INTERBANK DOLLAR DEPOSITS (In percentage points, by maturity)

Spread ^a	1972-1984	1985-1998
Commercial Paper^b		
Volatility ^c		
One month	0.32	0.12
Three months	0.25	0.13
Size		
One month	0.49	0.15
Three months	0.53	0.15
London Interbank Dollar Deposits^d		
Volatility ^c		
One month	0.51	0.41
Three months	0.37	0.43
Size		
One month	1.37	0.60
Three months	1.65	0.69

SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve and the London *Financial Times*.

- a. Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.
- b. Short-term debt issued by financial companies.
- c. Volatility is computed as the average over the indicated period of the moving, four-quarter, sample standard deviation.
- d. The rate used is LIBOR—the London interbank offer rate.

FIGURE 6. VOLATILITY OF INTEREST RATE SPREADS FOR ONE-MONTH LONDON INTERBANK DOLLAR DEPOSITS AND ONE-MONTH COMMERCIAL PAPER



SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve and the British Bankers' Association.

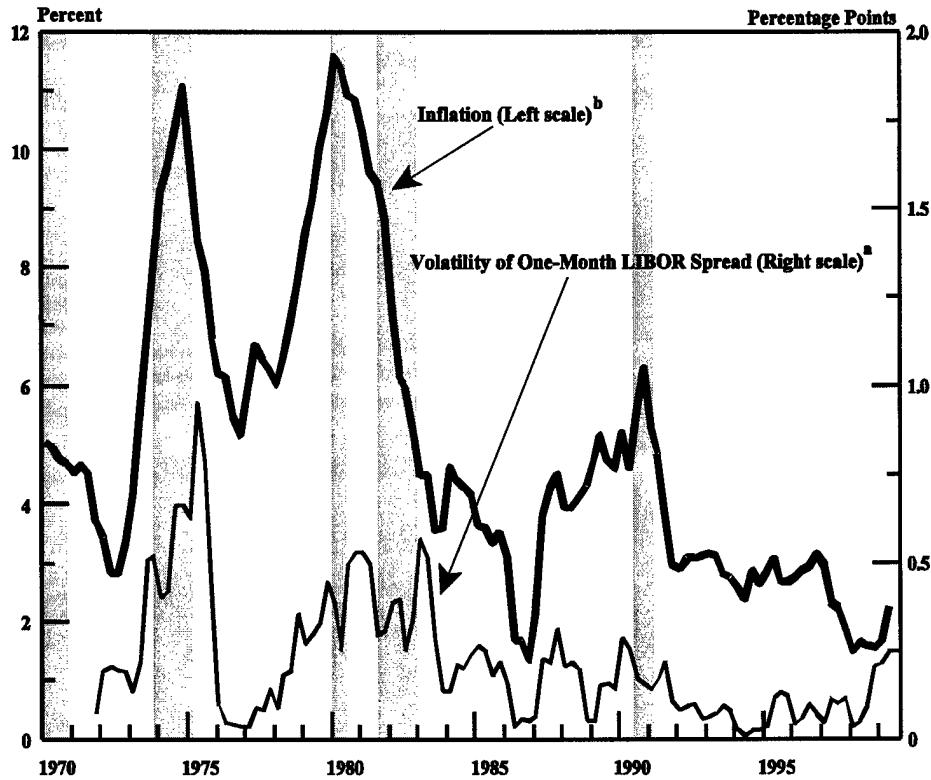
NOTES: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

Volatility is computed as the average over the indicated period of the moving, four-quarter, sample standard deviation. Data are drawn from the first quarter of 1972 through the fourth quarter of 1998.

a. The rate on London interbank dollar deposits is known as LIBOR—the London interbank offer rate.

b. Commercial paper is defined here as short-term debt issued by financial companies.

FIGURE 7. INFLATION AND THE VOLATILITY OF INTEREST RATE SPREADS
FOR ONE-MONTH LONDON INTERBANK DOLLAR DEPOSITS



SOURCE: Congressional Budget Office using data from the Board of Governors of the Federal Reserve, the British Bankers' Association, and the Department of Commerce.

NOTES: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

Volatility is computed as the average over the indicated period of the moving, four-quarter, sample standard deviation.

a. The rate on London interbank dollar deposits is known as LIBOR—the London interbank offer rate.

b. Measured as the consumer price index for all urban consumers.

CHAPTER III

PROJECTING INTEREST RATE SPREADS

Although the Congressional Budget Office has routinely projected interest rates on Treasury bills as part of its economic and budget outlook, it has not ordinarily projected commercial paper rates or the London interbank offer rate. With the rate on three-month commercial paper replacing the Treasury bill rate as the benchmark in the student-loan program for the next 42 months, CBO will make projections about the behavior of the new reference rate as part of its outlook. In developing a framework for those projections, plausibility and consistency with CBO's current projection procedures should be guiding principles. CBO formulated its model for projecting interest rate spreads on that basis. After using the model to produce cost estimates for the alternative-rate proposals considered in 1997, CBO has since revised it to incorporate more recent economic data and trends.

CBO'S INITIAL ALTERNATIVE-RATE PROJECTIONS

CBO's model for projecting interest rates on commercial paper and London interbank dollar deposits builds on work for its annual economic and budget outlook, which CBO prepares at the beginning of the year and updates at midyear. The outlook's horizon is 10 years; it comprises a short-term projection, or forecast, for a two-year span and a medium-term projection for the remaining eight years.¹ Over the medium term, CBO attempts to approximate average, or trend, relationships rather than project cyclical movements. Nevertheless, its projections take into account the possibility of booms and recessions. To identify trends, analysts use historical data for such factors as the growth of the labor force, the rate of national saving, and the growth of productivity. For Treasury interest rates, CBO bases its projections on underlying trends of real (inflation-adjusted) interest rates and inflation. The projections reflect CBO's baseline figures for government borrowing.

In 1997, CBO projected interest rates on commercial paper and the London interbank offer rate when they were first proposed as alternatives to Treasury bill rates in federal student-loan formulas. Over the projection period, analysts assumed that rates on commercial paper and LIBOR adjusted gradually to levels determined by their historical average spreads, which were calculated against Treasury bill rates using data from the early 1970s to late 1997. As discussed earlier, that period

1. The two-year forecast describes the likely evolution of the business cycle and is usually similar to the *Blue Chip* consensus (an average of the forecasts produced by approximately 40 to 50 private-sector economists).

encompassed many shocks that had dissimilar effects on commercial paper and LIBOR spreads.

The Asian financial turmoil of 1998 suggested that CBO needed to augment the approach it took in 1997 for projecting the two alternative-rate spreads. During the crisis, spreads rose sharply but not by as much as during the 1970s to mid-1980s. The weaker hike in 1998 partly reflects the structural changes mentioned earlier (for example, lower inflation) that have encouraged integration of the two segments of the money market. But the spreads' smaller expansion in 1998 also reflects the confluence of favorable cyclical conditions. Following some difficulties in the early 1990s, industrial corporations and financial institutions, as well as the governments of the United States, the United Kingdom, and Western Europe, had come a long way by 1998 toward rebuilding their finances after the turbulence of the 1970s and 1980s. When they went to borrow in the commercial paper and London interbank markets, their improved balance sheets spurred lenders to offer them roughly similar credit-risk and liquidity premiums. Yet as noted earlier, participants in the money markets have not always faced similar premiums. Recognizing the need to factor in as much information as possible, CBO determined that its projections must make some allowance for cyclical circumstances that might have disparate effects on the commercial paper and London interbank markets.

CBO'S CURRENT MODEL FOR PROJECTING INTEREST RATE SPREADS

CBO's modeling of the future paths of the alternative rates uses the baseline projections of three-month Treasury bill rates developed for the economic and budget outlook as its core, together with assumptions about certain factors that can affect the direction of those paths. The model projects spreads between Treasury bill rates and the alternative rates as a function of such factors as the rate of inflation and the stance and stability of monetary policy. (Those "determining" factors are also known as explanatory variables.) As discussed in Chapter IV, CBO then uses the baseline spread equations of the model to estimate volatilities for the spreads. The model specifies interest rates as bond-equivalent yields, which requires adjusting yields quoted from the original sources for differences in maturity and type of instrument. The adjustments are necessary because London interbank dollar deposits pay explicit interest computed over the term of the deposit, whereas Treasury bills and commercial paper are discount instruments. That means they pay interest implicitly—by selling at a discounted price relative to the price at which they are redeemed at maturity.

Factors That Determine How Spreads Behave

Modeling in full the way spreads between interest rates on three-month Treasury bills and rates for the alternative instruments widen and narrow over time would require an almost limitless set of determining factors. But fewer variables, four of which are among the most important, can explain the broad aspects of the spreads' movements:

- o *Overall Interest Rates.* Higher overall rates should increase (and lower rates decrease) the spreads between Treasury bill rates and the alternatives if the credit-risk premium on commercial paper rates and LIBOR is proportional to those rates. Because CBO routinely projects the rate on three-month Treasury bills, it uses that as a convenient measure of overall interest levels.
- o *Monetary Policy Stance.* Although many measures are available, a convenient one is the yield curve spread between long- and short-term Treasury rates—convenient because CBO already projects those rates for its economic and budget outlook. (The yield curve is the relationship formed by plotting the yields of otherwise comparable fixed-income securities against their terms of maturity.) Typically, a wider yield curve spread signifies an easier monetary policy, which is often accompanied by narrower spreads of commercial paper rates and LIBOR relative to Treasury bill rates. Spreads may also narrow because a less restrictive monetary policy eases investors' perceptions of risk. (A narrow or sometimes negative yield curve spread would produce opposite effects.)
- o *Inflation Rate.* Commercial paper and LIBOR spreads have tended to be large when inflation is high, probably because in the past, high inflation has been associated with substantial volatility in markets and, presumably, heightened perceptions of credit risk.
- o *Volatility of the Federal Funds Rate* (as a measure of the volatility of monetary policy). Historically, the volatility of U.S. monetary policy has had less effect on commercial paper rates than on LIBOR, probably because of the close connection between interbank dollar markets in the United States and in London. By incorporating the volatility of monetary policy in its model, CBO can also gauge the effect of the more stable monetary policy of recent years on the narrowed gap between London interbank and commercial paper rates.

Historical Period

In estimating the relationship between interest rate spreads and the determining factors, CBO used historical data from 1971 to 1998. That span takes in diverse patterns for interest rates, varying levels of inflation, differences in the stance and volatility of monetary policy, and the shifting credit risks of the banks and corporations that participate in commercial paper and interbank markets. The diversity provided a reasonable test of the usefulness of CBO's framework for projecting spreads.

Yet at the same time, using that long a span of data requires analysts to account for structural changes that have influenced the spreads' behavior and especially their volatility. The economy's overall improvement in the 1990s is the most significant structural change affecting interest rate spreads. Compared with the 1970s and 1980s, inflation has subsided, interest rates have declined, large federal deficits have disappeared, and monetary policy has been relatively stable. Those improvements helped narrow interest rate spreads during the 1990s, and CBO has incorporated those structural changes into its projections. Thus, in the model, inflation and interest rates remain lower than in the past, the federal budget shows a surplus, and monetary policy reflects the improved economic outlook. The result is smaller projected commercial paper and LIBOR spreads (measured against three-month Treasury bills) compared with spreads from the early 1970s to the mid-1980s. In CBO's estimates, spreads between commercial paper rates and LIBOR also narrow—for as long as the economy's overall improvement is expected to hold.

Why the spreads' volatilities have lessened is still unclear, even after taking into account the role played by the determining factors. To economic statisticians, the unexplained portion of the observed change in volatility is a condition called heteroskedasticity. Its presence suggests that volatility has changed in response to some underlying factor or set of factors. To account for that change, CBO's model uses a procedure that gives relatively less weight to data from periods when volatility is great (and the spreads are large) and relatively more weight to data from times when volatility is less (see Table 7). Smoothing the volatility in that way reduces the influence of extreme, chaotic factors, such as the oil price shocks that occurred in the 1970s, and yields a more accurate estimate. (For more details of the weighting procedure, see the appendix.)

Adjusting the model for the change in volatility achieves two objectives. First, it allows analysts to use a sufficiently long historical sequence to detect the role played by each determinant of a spread. (Another approach would have been to discard data when volatility was substantial, but that would needlessly throw away valuable information and prevent a more complete understanding of a spread's behavior.) Second, as explained in Chapter IV, accounting for the decline in volatility

TABLE 7. CBO'S WEIGHTING OF DATA PERIODS TO ADJUST FOR CHANGES IN THE VOLATILITY OF INTEREST RATE SPREADS FOR COMMERCIAL PAPER AND LONDON INTERBANK DOLLAR DEPOSITS
(In percent, by maturity)

Spread ^a	Weighting	
	1971-1984	1985-1998
Commercial Paper ^b		
One month	38	62
Three months	41	59
London Interbank Dollar Deposits ^c		
One month	35	65
Three months	36	64
Memorandum:		
Equal Weighting (For comparison)	50	50

SOURCE: Congressional Budget Office.

- a. Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.
- b. Short-term debt issued by financial companies.
- c. The rate used is LIBOR—the London interbank offer rate.

with such procedures improves estimates of the probability distribution of the range of variation in the spreads.

Illustrative Projections

CBO conducted an exercise to illustrate its approach for projecting the approximate behavior of interest rate spreads. As explanatory variables, CBO used interest rates on three-month Treasury bills; the yield curve spread, measured by the difference between rates on 10-year Treasury notes and three-month Treasury bills; inflation, measured by the percentage change in the consumer price index (specifically, the index for all urban consumers, or CPI-U); and monetary policy volatility, measured as the volatility of the federal funds rate. Projections of Treasury bill rates, the yield curve spread, and CPI-U inflation were based on CBO's December 1998 baseline. As noted earlier, the 1990s have seen much less volatility in monetary policy than in the past. Including the volatility of the federal funds rate as a factor thus assumes that monetary policy and the economy will remain relatively stable. Although the same determining factors were used throughout the exercise, the factors' effects can

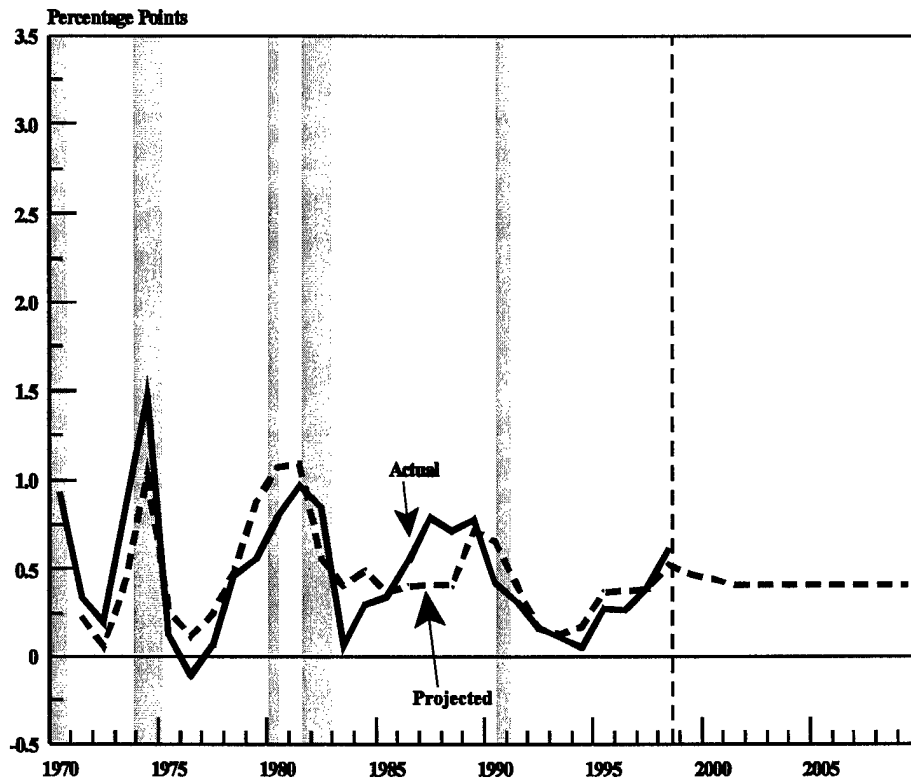
be expected to differ according to the spread being considered and the alternative instrument's maturity (whether one month or three months). All of the interest rate spreads discussed below were calculated against the three-month Treasury bill.

One-Month Commercial Paper. The results from CBO's model for the one-month commercial paper spread appear satisfactory for two reasons (see Figure 8). First, for the 1971-1998 period, the model's estimate of the spread as a function of the determining factors tracks reasonably closely with the actual spread during that time. Second, the projected spreads for 1999 to 2009 move much closer to the average of the 1985-1998 period than to the average of the earlier period, which indicates that the model's projections are consistent with the economy's overall expected improvement.

Three-Month Commercial Paper. In the past, the average for the three-month commercial paper spread was less than that for the one-month spread; however, in CBO's model, projections of the three-month spread for 1999 to 2009 are slightly above the historical average and close to recent experience (see Figure 9). The spread's stability reflects the lack of economic shocks during the projection period in contrast to the mid-1970s and early 1980s, when sudden economic jolts drove one-month commercial paper rates to much higher levels than rates on three-month commercial paper.

One-Month LIBOR. The model's results for the one-month LIBOR spread show that CBO's approach can explain the spread's historical behavior, including the narrowing described earlier (see Figure 10). The determining factors affect LIBOR spreads differently from commercial paper spreads. For example, fluctuations in three-month Treasury bill rates influence the one-month LIBOR spread more strongly than the commercial paper spread, probably because interbank premiums for credit and liquidity risks are more influenced by overall movements in interest rates. A steep yield curve also affects the LIBOR spreads more than the commercial paper spreads, suggesting that an easier monetary policy influences the interbank market more than the market for commercial paper. Furthermore, high levels of inflation and more volatility in monetary policy have stronger effects on credit-risk premiums in interbank markets. But the model also projects future LIBOR spreads that are much lower than in the past. Those lower spreads stem from CBO's baseline assumptions of lower overall rates of interest and inflation and a stable monetary policy.

FIGURE 8. ACTUAL AND PROJECTED INTEREST RATE SPREADS
FOR ONE-MONTH COMMERCIAL PAPER

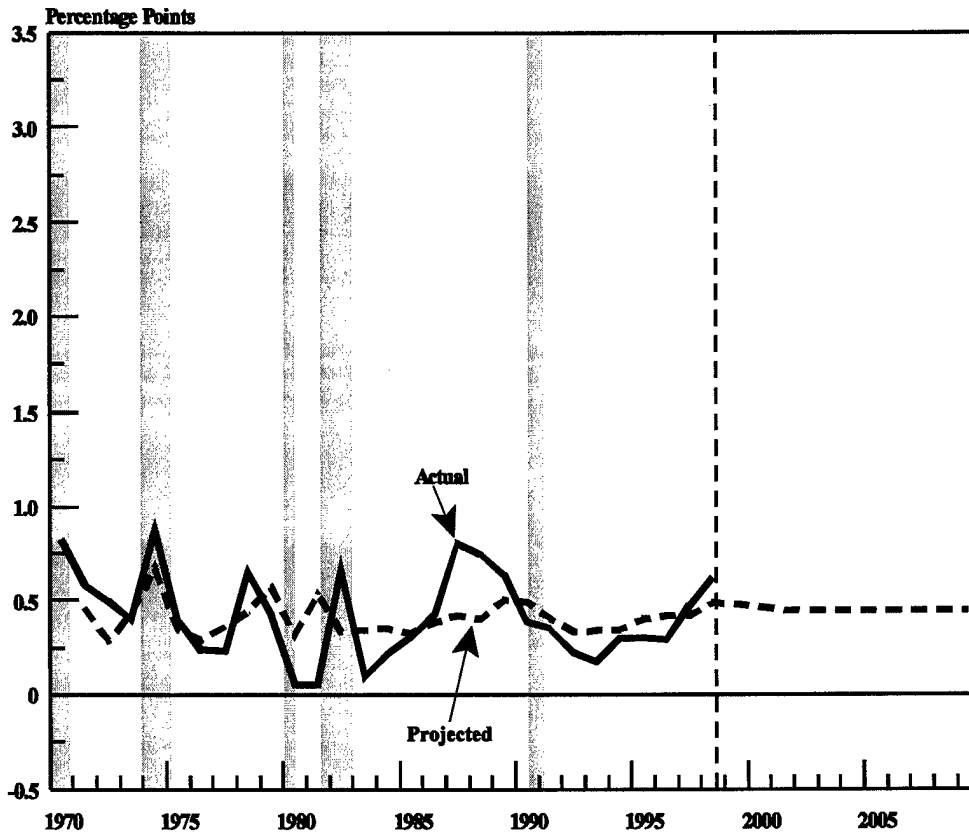


SOURCES: Actual values are Congressional Budget Office calculations based on data from the Board of Governors of the Federal Reserve. Projected values are derived from CBO's model for estimating alternative interest rates for the federal student-loan program.

NOTES: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

Commercial paper is defined here as short-term debt issued by financial companies.

FIGURE 9. ACTUAL AND PROJECTED INTEREST RATE SPREADS
FOR THREE-MONTH COMMERCIAL PAPER

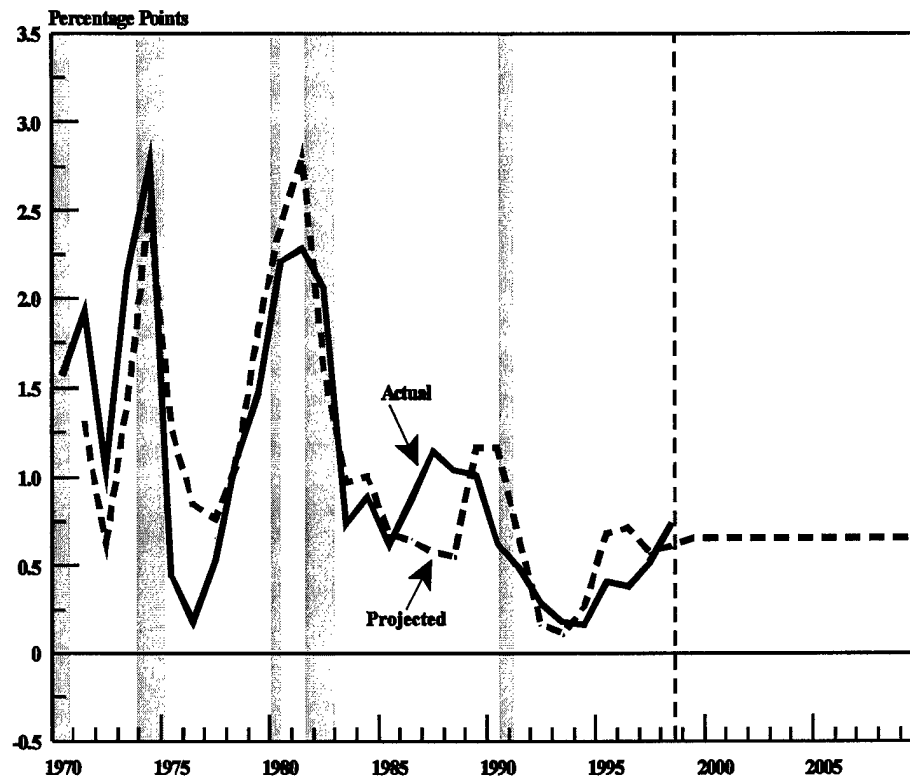


SOURCES: Actual values are Congressional Budget Office calculations based on data from the Board of Governors of the Federal Reserve. Projected values are derived from CBO's model for estimating alternative interest rates for the federal student-loan program.

NOTES: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

Commercial paper is defined here as short-term debt issued by financial companies.

FIGURE 10. ACTUAL AND PROJECTED INTEREST RATE SPREADS FOR ONE-MONTH LONDON INTERBANK DOLLAR DEPOSITS



SOURCES: Actual values are Congressional Budget Office calculations based on data from the Board of Governors of the Federal Reserve. Projected values are derived from CBO's model for estimating alternative interest rates for the federal student-loan program.

NOTES: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

The rate on London interbank dollar deposits is known as LIBOR—the London interbank offer rate.

Three-Month LIBOR. CBO's model produced three-month LIBOR spreads that are quite similar to those described above for one-month LIBOR (see Figure 11). The determining factors appear to account for the broad movements of the spread over all three decades—the 1970s, 1980s, and 1990s—which in turn suggests why LIBOR spreads were wide before the 1990s and why they have not only narrowed in this decade but also come close to commercial paper spreads. The determining factors also lead to narrow projected spreads for the decade ahead—as long as the CBO economic outlook remains favorable.

Eurodollar Deposits. Closely associated with LIBOR are Eurodollar deposit rates—the rates paid on deposits of dollar-denominated funds by banks in London and in cities outside the United States to corporations and other investors that are not part of the interbank community. Unlike LIBOR, which is not published regularly or even frequently by the U.S. government, estimates of Eurodollar deposit rates are available daily from the Federal Reserve (for reference purposes only) on maturities of one, three, and six months. Those estimates are bid rates for deposits in London. Spreads between LIBOR and rates on Eurodollar deposits have tended to be relatively narrow (see Table 8).

One criterion for any benchmark rate for the student-loan program might be whether the rates could be provided by the Federal Reserve. Consequently, CBO developed equations to estimate the spreads between one-month and three-month Eurodollar deposit rates and rates on three-month Treasury bills. In both cases, the

TABLE 8. AVERAGE INTEREST RATE SPREADS BETWEEN RATES ON LONDON INTERBANK DOLLAR DEPOSITS AND EURODOLLAR DEPOSITS
(In percentage points, by maturity)

Maturity	1971-1998	1980-1998	1985-1998
One Month	0.09	0.13	0.12
Three Months	0.09	0.13	0.12

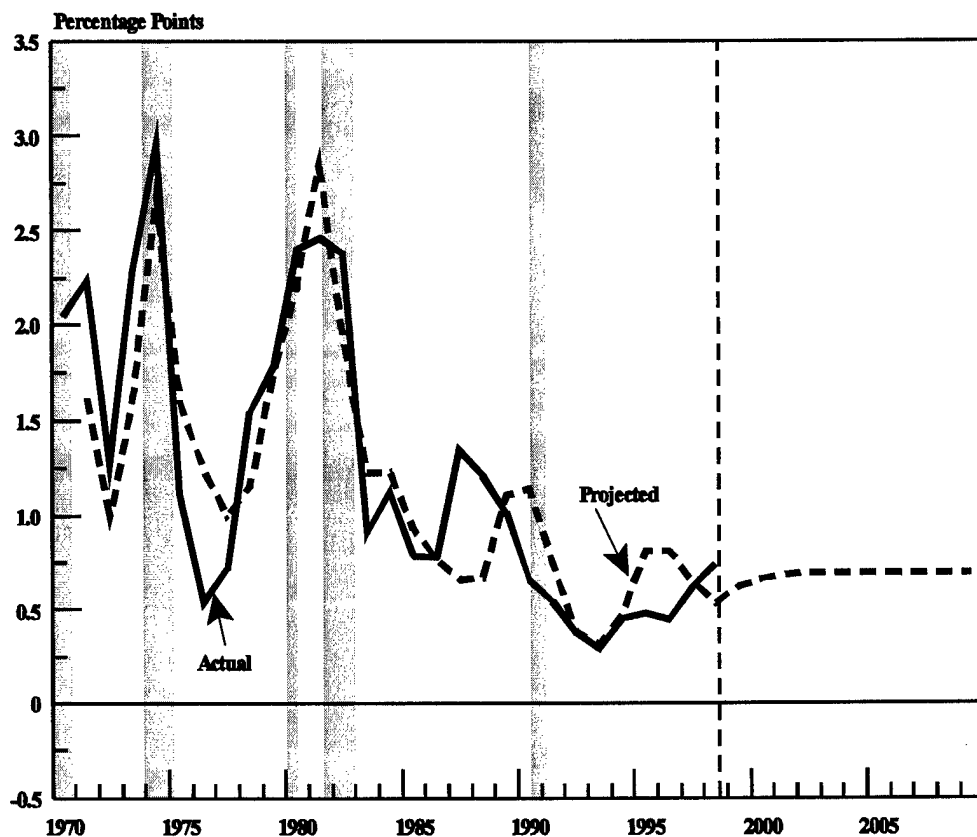
SOURCE: Congressional Budget Office based on data from the Board of Governors of the Federal Reserve and the London *Financial Times*.

NOTES: Spreads (the differences between rates) are computed using interest rates converted to bond-equivalent yields.

The rate on London interbank dollar deposits is LIBOR—the London interbank offer rate.

Eurodollar deposits are dollar-denominated funds placed in banks in London and in cities outside the United States by investors that are not part of the interbank community.

FIGURE 11. ACTUAL AND PROJECTED INTEREST RATE SPREADS FOR THREE-MONTH LONDON INTERBANK DOLLAR DEPOSITS



SOURCES: Actual values are Congressional Budget Office calculations based on data from the Board of Governors of the Federal Reserve. Projected values are derived from CBO's model for estimating alternative interest rates for the federal student-loan program.

NOTES: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

The rate on London interbank dollar deposits is known as LIBOR—the London interbank offer rate.

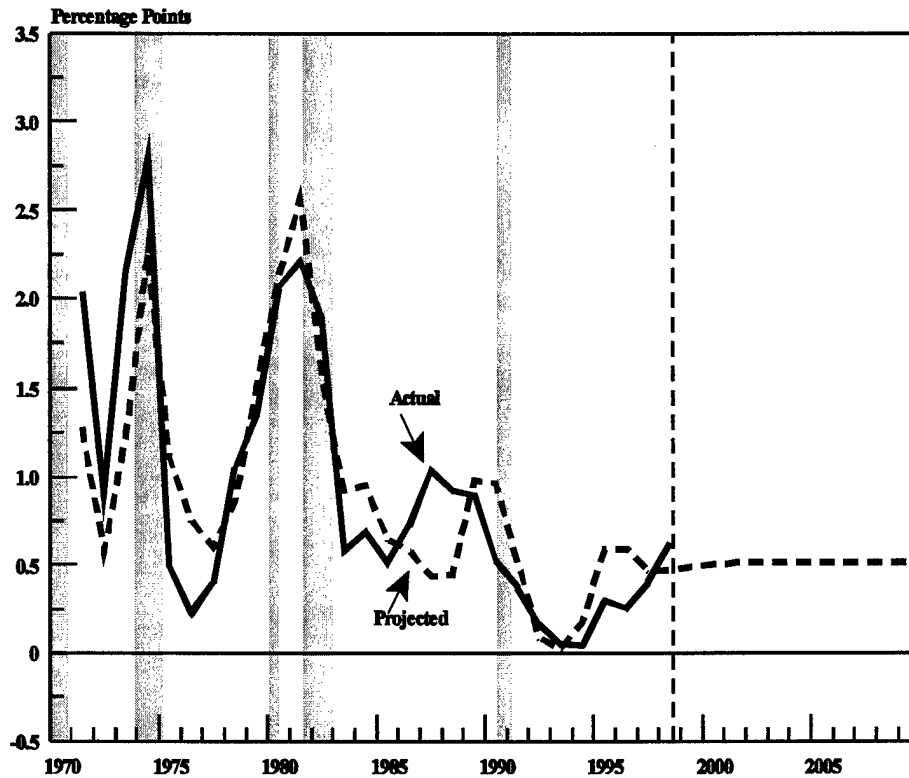
framework was the same as that used for the LIBOR spreads, and the results were as satisfactory (see Figures 12 and 13).

Conclusion

The results from CBO's model indicate that with one exception, spreads between interest rates on three-month Treasury bills and the rates on the alternative financial instruments are narrow compared with past averages (see the top panel of Table 9). The largest declines relative to the past occur in LIBOR and Eurodollar spreads. The exception is the spread for three-month commercial paper, which is projected to be slightly larger than the spread for one-month commercial paper instead of slightly smaller, as in the past.

Over the long run, why have the projected spreads fallen below their historical averages in almost all cases? The main reason is CBO's economic outlook for the next several years. Compared with historical trends, Treasury bill rates are lower (see the bottom panel of Table 9). Furthermore, yield curves are flatter, inflation rates are more modest, and the volatility of the federal funds rate is assumed to be less (see Table 10). Those projected improvements in the economic outlook feed directly into CBO's projections of the spreads and help narrow them.

FIGURE 12. ACTUAL AND PROJECTED INTEREST RATE SPREADS FOR ONE-MONTH EURODOLLAR DEPOSITS

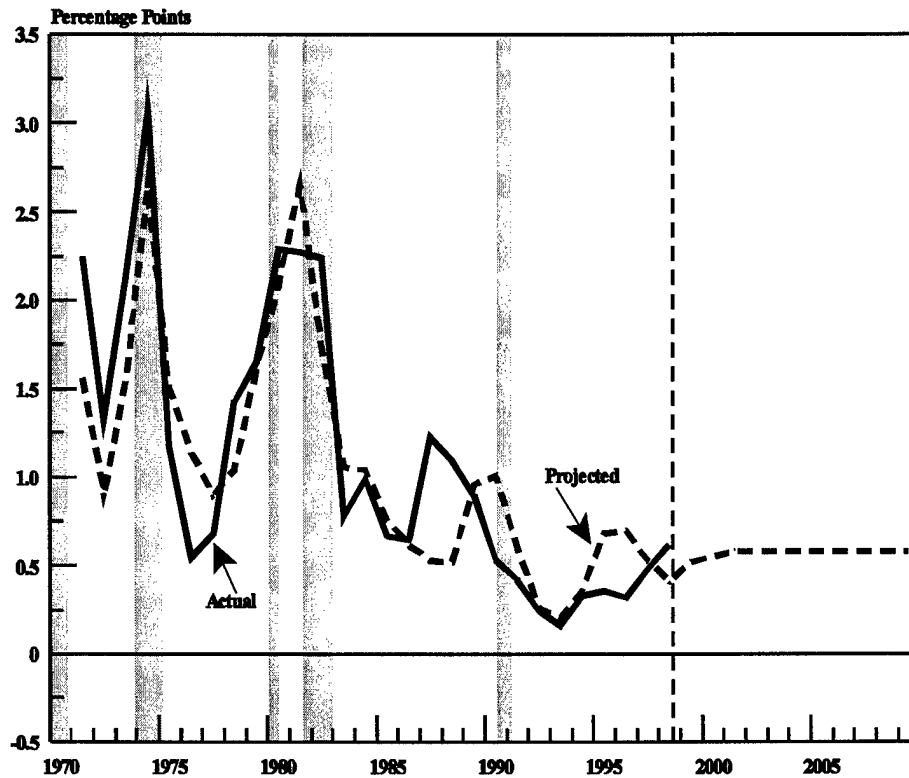


SOURCES: Actual values are Congressional Budget Office calculations based on data from the Board of Governors of the Federal Reserve. Projected values are derived from CBO's model for estimating alternative interest rates for the federal student-loan program.

NOTES: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

Eurodollar deposits are dollar-denominated funds placed in banks in London and in cities outside the United States by investors that are not part of the interbank community.

FIGURE 13. ACTUAL AND PROJECTED INTEREST RATE SPREADS FOR THREE-MONTH EURODOLLAR DEPOSITS



SOURCES: Actual values are Congressional Budget Office calculations based on data from the Board of Governors of the Federal Reserve. Projected values are derived from CBO's model for estimating alternative interest rates for the federal student-loan program.

NOTES: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

Eurodollar deposits are dollar-denominated funds placed in banks in London and in cities outside the United States by investors that are not part of the interbank community.

TABLE 9. ILLUSTRATIVE PROJECTIONS OF SPREADS AND INTEREST RATES
FOR SHORT-TERM FINANCIAL INSTRUMENTS USING CBO'S JANUARY
1999 ECONOMIC ASSUMPTIONS (By maturity)

	Average, 1971- 1998	Actual, 1998	1999	2000	2001	2002	2003	2004	2005	2009
Spreads (Percentage Points)^a										
Commercial Paper ^b										
One month	0.45	0.61	0.47	0.44	0.41	0.41	0.41	0.41	0.41	0.41
Three months	0.41	0.61	0.47	0.46	0.44	0.44	0.44	0.44	0.44	0.44
London Interbank Dollar Deposits ^c										
One month	1.01	0.73	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
Three months	1.19	0.73	0.62	0.66	0.68	0.69	0.69	0.69	0.69	0.69
Eurodollar Deposits ^d										
One month	0.91	0.61	0.49	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Three months	1.10	0.61	0.52	0.55	0.58	0.58	0.58	0.58	0.58	0.58
Interest Rates (Percent)										
Three-Month Treasury Bills	6.97	4.91	4.56	4.61	4.61	4.61	4.61	4.61	4.61	4.61
Commercial Paper ^b										
One month	7.42	5.52	5.03	5.06	5.02	5.02	5.02	5.02	5.02	5.02
Three months	7.38	5.52	5.04	5.07	5.06	5.06	5.06	5.06	5.06	5.06
London Interbank Dollar Deposits ^c										
One month	7.98	5.65	5.22	5.28	5.27	5.27	5.27	5.27	5.27	5.27
Three months	8.16	5.64	5.18	5.27	5.30	5.30	5.30	5.30	5.30	5.30
Eurodollar Deposits ^d										
One month	7.88	5.52	5.05	5.12	5.13	5.13	5.13	5.13	5.13	5.13
Three months	8.06	5.52	5.08	5.17	5.19	5.20	5.20	5.20	5.20	5.20

SOURCES: Congressional Budget Office using data from the Board of Governors of the Federal Reserve and the London *Financial Times*. Projections of Treasury bill rates are taken from Congressional Budget Office, *The Economic and Budget Outlook: Fiscal Years 2000-2009* (January 1999). The projections of other rates are based on econometric models (see the appendix for further details).

- a. Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.
- b. Short-term debt issued by financial companies.
- c. The rate used is LIBOR—the London interbank offer rate.
- d. Eurodollar deposits are dollar-denominated funds placed in banks in London and in cities outside the United States by investors that are not part of the interbank community.

TABLE 10. AVERAGE LEVELS OF DETERMINING FACTORS USED IN CBO'S MODEL FOR PROJECTING INTEREST RATE SPREADS

Factor	1971-1998	1999-2000
Interest Rate on Three-Month Treasury Bills (Percent)	6.97	4.61
Treasury Bill Yield Curve (Percentage points) ^a	1.41	0.75
Inflation (Percent) ^b	5.03	2.61
Federal Funds Volatility (Percentage points) ^c	1.14	0.72

SOURCES: Congressional Budget Office using data from the Board of Governors of the Federal Reserve and the Department of Labor, Bureau of Labor Statistics. Projections are taken from Congressional Budget Office, *The Economic and Budget Outlook: Fiscal Years 2000-2009* (January 1999).

- a. The yield curve is the relationship formed by plotting the yields of otherwise comparable fixed-income securities against their terms of maturity.
- b. As measured by the consumer price index for all urban consumers.
- c. Volatility is computed over the indicated period as the square root of the eight-quarter moving average of the squared deviation of the federal funds rate. Deviation is measured as the difference between the log first-difference change of the federal funds rate and the trend of the log first-difference change in the rate. Trend is measured as an eight-quarter moving average.

CHAPTER IV

PROJECTING INTEREST RATE VOLATILITIES

To estimate the cost of the federal student-loan program, Congressional Budget Office analysts must know more than just the baseline path of interest rates. Since special-allowance payments to lenders are triggered if interest rates exceed certain predetermined thresholds, or caps, during the projection period, the cost of the program depends on both the path of a particular interest rate and its potential volatility. Therefore, any cost estimate for the student-loan program requires estimating both the mean and the variance for each rate.

CBO used Monte Carlo simulations, a statistical inference technique, to gauge the variance, or uncertainty, surrounding its projections of interest rate spreads for commercial paper and London interbank deposits.¹ The Monte Carlo approach uses a statistical model to introduce random variation into the spread projections and estimate the likelihood that those alternative benchmark rates will exceed the interest rate cap of 8.25 percent for student borrowers. The method calls for constructing a large number of simulated (hypothetical) projections of an economic variable such as an interest rate and then computing the probability distribution of those results. To construct the simulations, CBO analysts used the model for projecting spreads that was discussed in Chapter III. However, to approximate the uncertainty inherent in the future evolution of interest rates, analysts randomly varied each of the model's "baseline" spread equations in two ways.

- o First, instead of holding the values for the explanatory variables (such as inflation or the yield curve) in each equation to their levels in CBO's economic outlook, analysts simulated them to allow random variation, thus permitting uncertainty about the future vagaries of the overall economy to affect the spreads.
- o Second, for each period of the simulation, analysts added a random term to each of the spread equations; the term was based on the historical properties of the residuals from that equation. (Residuals are the errors that occur in regression equations.)

Each of the simulated projections thus started at the same level and evolved according to the baseline spread equation. However, each projection incorporated

1. A common application of Monte Carlo simulations is approximating the sampling distribution of a test statistic—for example, a parameter in a regression equation.

a different path for the explanatory variables as well as a different set of random economic shocks.

UNCERTAINTY ASSOCIATED WITH THE EXPLANATORY VARIABLES

In constructing a set of simulations, the projection for each explanatory variable must be consistent with the variable's historical behavior and with the projections for all of the other explanatory variables. To ensure both types of consistency, analysts use a model, or system of interrelated equations. CBO uses an econometric model to compute its baseline set of economic assumptions (which constitute the economic outlook). However, that model is too large for stochastic simulations—those involving random variation. To compute the hypothetical projections of the explanatory variables, CBO adopted a simpler approach called vector autoregression, or VAR. VAR is a method for estimating the statistical relationships among a set of economic variables without placing many restrictions on those relationships. In effect, it allows the data to determine which links among the variables are strong and which are weak. In contrast, traditional methods—to make estimation easier—use economic theory to place as many restrictions as possible on the structure of statistical models. Advocates of VAR contend that such restrictions are inappropriate because in a complex economy, most variables in macroeconomic models are endogenous (that is, they are affected by the other variables in the system).

Under the VAR approach, a system in which all of the variables are endogenous can be constructed as a set of equations in which each variable is a function of its own previous, or lagged, values and the lagged values of all of the other variables in the system. Each equation can be estimated using the ordinary least-squares method because the right-hand side of the equation contains only predetermined variables. Estimating equations under VAR involves little more than determining the variables to be included in the system and how long the lags should be.

CBO's VAR model used the following variables: the 10-year Treasury note rate, the spread between the 10-year note rate and the three-month Treasury bill rate, inflation as measured by the consumer price index for all urban consumers, the rate of unemployment, a measure of volatility, and the spread between the 10-year Treasury note rate and the 30-year bond rate. Each equation included three lags of each variable in the model and used quarterly data from 1961 through the third quarter of 1998. The results were not sensitive to the length of the lag.

UNCERTAINTY ASSOCIATED WITH THE ALTERNATIVE RATES

The second source of random variation in the simulations for the alternative rates stems from the residuals of the baseline spread equations. When estimated over time,

regression equations do not explain all of the variation in the so-called dependent variable (in this case, the alternative rates). Analysts thus assume that the residuals arise from completely random shocks to the dependent variable. To allow the simulations to capture the uncertainty imparted by those shocks, the value of the spread projected by the baseline equation incorporated a shock "term." Unlike the method used in many Monte Carlo exercises, however, those shocks were not randomly drawn from a statistical distribution.

As discussed in Chapter III, CBO's statistical tests indicated that the residuals of the spread equations were heteroskedastic—their variance was not constant over time. CBO's estimating methods corrected for heteroskedasticity by exploiting the positive correlation of the variance of the residuals with their lagged values and with the rate of inflation.² The method CBO used to correct for heteroskedasticity, which improved the statistical efficiency of the baseline spread equations, also supplied the shocks noted above. The correction reduced the estimated volatility of the interest rates during the projection period because the estimated volatility of the residuals in recent years has been low and because CBO's baseline projection for inflation is lower than the historical average.

PROBABILITIES ASSOCIATED WITH THE ALTERNATIVE RATES

CBO computed the probabilities of exceeding the interest rate cap in the student-loan program for each of the alternative rates considered in this memorandum. Using 1,000 simulations of the model, in which each simulation was a projection that included random variation in the explanatory variables and in the residuals of the spread equations, analysts counted the number of occurrences (out of 1,000) in which the interest rate exceeded a specific threshold, thus approximating the probability distributions of the projections (see Table 11).

Because each of the alternative rates is highly correlated with the rate for three-month Treasury bills, it is not surprising that the probabilities of the rates' exceeding the threshold are broadly similar to those for Treasury bills. For the interest rate on three-month commercial paper in particular, the distribution of estimated probabilities is almost indistinguishable from that for Treasury bills. Probabilities for the rate on one-month commercial paper are only slightly higher. The London interbank offer rate appears to be more volatile than the rates on commercial paper: the estimated probabilities for LIBOR surpass those for three-month Treasury bills by slightly larger amounts than do the rates on commercial paper.

2. CBO used an estimating technique known as generalized autoregressive-conditional heteroskedasticity in its correction. The technique adds a regression equation that explains the variance of the residuals (see the appendix).

TABLE 11. ILLUSTRATIVE PROBABILITIES FOR INTEREST RATES ON
SHORT-TERM FINANCIAL INSTRUMENTS (In percent, by maturity)

	Probability That Interest Rate Will Exceed Its Baseline Rate by at Least				
	0 p.p.	1 p.p.	2 p.p.	3 p.p.	4 p.p.
Three-Month Treasury Bills	49	34	20	11	5
Commercial Paper ^a					
One month	49	35	22	12	6
Three months	49	34	21	11	5
London Interbank Dollar Deposits ^b					
One month	49	36	24	14	8
Three months	49	36	24	14	8

SOURCE: Congressional Budget Office.

NOTES: The entries in the table are averages of the probability that a particular interest rate will exceed its baseline level (by 0 percentage points, 1 percentage point, and so forth) each year from 1999 through 2030.

p.p. = percentage points.

a. Short-term debt issued by financial companies.

b. The rate used is LIBOR—the London interbank offer rate.

APPENDIX

ESTIMATING METHODS AND

ECONOMETRIC DETAIL

As noted earlier, the Congressional Budget Office's (CBO's) projections of alternative interest rates used a statistical model in which spreads were estimated as a function of four factors: rates on three-month Treasury bills, the spread between a long-term and a short-term interest rate, the level of inflation, and the volatility of the interest rate on federal funds.¹ Each projection equation had the same set of explanatory variables, but each yielded a different set of coefficients.

THE MODEL

CBO's methods for estimating the model drew from standard econometric theory in selecting the appropriate form of the spread and the techniques to be applied. The following equations and the succeeding discussion incorporate a summary of those methods.

The spread between the alternative interest rates and the rate on three-month Treasury bills was modeled as follows:
where for $R_{j,t}$, the upper case R signifies an interest rate (expressed as a bond-

$$\begin{aligned} \text{Equation 1.} \quad \ln \left\{ \frac{(1 + R_{j,t})}{(1 + R_{Tbill,t})} \right\} &= a_{j,0} + a_{j,1} \ln \{1 + R_{Tbill,t-1}\} \\ &+ a_{j,2} \ln \left\{ \frac{(1 + R_{Tnote,t-1})}{(1 + R_{Tbill,t-1})} \right\} \\ &+ a_{j,3} \ln \{1 + Inflation_{t-1}\} \\ &+ a_{j,4} \ln \{1 + \sigma_{Fedfunds,t-1}\} \\ &+ a_{j,5} D74Q3 + a_{j,6} D80Q4 + u_{j,t} \end{aligned}$$

equivalent yield) and the subscript j stands for one-month commercial paper, three-month commercial paper, one-month London interbank offer rate, three-month LIBOR, one-month Eurodollar, and three-month Eurodollar, respectively; "ln"

1. Under the current terms of the student-loan program, payments to lenders are adjusted quarterly on the basis of a quarterly average of weekly yields. CBO thus estimated the model using quarterly data.

signifies the natural logarithm of the expression within braces; the two variables preceded with an upper case D signify (for reasons described later) that the variable takes on a value of 1 in the year and quarter (1974Q3 and 1980Q4) and zero otherwise; and the variable $u_{j,t}$ represents unobservable random factors, or residuals.

In equation 1, the spread appears in ratio form to the left of the equal sign. It is expressed as the logarithm of the ratio of 1 plus the interest rate under examination to 1 plus the rate on three-month Treasury bills. That form of the spread is approximately equal to the numerical difference between interest rates when rates are low. CBO analysts chose it to help reduce the effect of extreme values of the spread on the statistical estimates of parameters ($a_{j,0}, \dots, a_{j,6}$). (For example, it reduces peak values of the spread between one-month LIBOR and three-month Treasury bill rates by about 40 to 50 basis points compared with that spread constructed as the simple difference between the two rates.) Even so, the two extreme values of the spread (which occurred in the third quarter of 1974 and the fourth quarter of 1980) were still too large to be accounted for by the determining factors despite the logarithmic transformation. As a result, two “dummy” variables, $D74Q3$ and $D80Q4$, were introduced to help remove the effects of those two extreme values on the parameter estimates. Omitting the dummy variables would alter the projections of the spreads. Most important, it would significantly increase the uncertainties associated with them and therefore the estimated probability of the rates’ exceeding any given threshold.

Equation 2 is the part of the structural model dealing with nonuniform variations in the volatility of the residuals of the spread—for example, variation during the period before the mid-1980s, when inflation was climbing and rates were high, compared with variation since then, when inflation has declined and rates are low:

$$\text{Equation 2.} \quad \ln\{u_{j,t}^2\} = b_{j,0} + b_{j,1} \ln\{u_{j,t-1}^2\} + b_{j,2} \ln\{1 + \text{Inflation}_t\}$$

Nonuniform volatility of the residuals introduces heteroskedasticity, which is characterized in part by a periodic clustering of large values. That type of time variation giving rise to nonuniformity is known as autoregressive-conditional heteroskedasticity, or ARCH.

Accounting for ARCH, as in equation 2, improves empirical estimates of the parameters of equation 1 over longer data intervals, such as the nearly 30-year period encompassing the 1970s through the 1990s. Not accounting for ARCH could mean that the potential range of variation around the estimated values of the parameters in equation 1 would be too large to yield much confidence in the estimates themselves. An unattractive alternative would be to shorten the period of analysis—unattractive because a shorter period, such as the 1990s alone or the late 1980s to late 1990s, limits understanding of how the determining factors affect the spread.

Including ARCH also helps analysts develop reasonable probability ranges over the projection span. In particular, as specified in equation 2, the low inflation of the 1990s appears to have played an important role in reducing volatility. As such, a baseline projection of low inflation in the years ahead leads to projections of spreads with less volatility than might otherwise be the case. Less volatility in the spreads in turn produces probability ranges that are narrower than they might otherwise have been.

THE ESTIMATING PROCEDURE

CBO's estimating procedure is a sequence of three steps, which make up the method of generalized least squares. In the first step, equation 1 uses ordinary least squares to derive an estimate of the unobservable series of residuals $u_{j,t}$ (see Table A-1). The difference between the actual value of the spread and the value predicted by the equation yields the residuals used in the second step.

In that step, the residuals obtained from the first equation are squared to obtain a measure of the spread's volatility. That measure is then used along with the inflation rate to estimate equation 2 for each of the six spreads (see Table A-2). The projected volatility values are retrieved from this equation for the last step of generalized least squares.

In the third step, the square root of the projected volatility value is divided into all of the observable variables of equation 1, and the resulting equation is estimated by ordinary least squares. Of course, having divided each observation by the predicted volatility from equation 2 amounts to a reweighting of each observation (see Table A-3). The explicit reweighting of observations is a critical feature of the third step. Without it, each observation would have been weighted equally. With it, observations are weighted inversely to the degree of volatility found in equation 2. (Figures A-1 and A-2 show the weights for each spread.)

THE DATA SOURCES

Listed below are the data used in CBO's model and their sources:

- o *Commercial Paper Rates.* The interest rates paid by financial issuers. CBO used the quarterly average of daily data published by the Federal Reserve and converted to the bond-equivalent yield, or BEY.² Data for the

2. CBO drew the rates it used for commercial paper, Eurodollar deposits, Treasury securities, and federal funds from Board of Governors of the Federal Reserve, *Selected Interest Rates*, Federal Reserve Statistical Release H.15 (various dates).

period before the fourth quarter of 1997 were based on historical statistics gathered by the Federal Reserve Bank of New York. Data for the fourth quarter of 1997 and later were gathered by the Depository Trust Company and reported to the Federal Reserve Bank of New York.

- o *London Interbank Offer Rates.* Quarterly average of daily data published by the British Bankers' Association and converted to the BEY.
- o *Eurodollar Deposit Rates.* Quarterly average of daily data published by the Federal Reserve and converted to the BEY.
- o *Treasury Bill Rates.* Quarterly average of daily data on three-month Treasury bill rates sold in the secondary markets on a discount basis. The average, published by the Federal Reserve, was converted to the BEY.
- o *Ten-Year Treasury Note Rates.* Quarterly average of daily data on 10-year Treasury notes with constant maturity, as published by the Federal Reserve.
- o *Inflation.* Annualized quarterly percentage change of the consumer price index for all urban consumers. (The CPI-U is the quarterly average of monthly levels, published by the Bureau of Labor Statistics.)
- o *Federal Funds Volatility.* The square root of an eight-quarter moving average of the squared deviation of the federal funds rate. Deviation is measured as the difference between log first-difference change of the federal funds rate and the trend of log first-difference change in the rate. Trend is measured as an eight-quarter moving average. CBO used quarterly data based on the average of daily data published by the Federal Reserve.

TABLE A-1. CBO ESTIMATES OF INTEREST RATE SPREADS USING ORDINARY LEAST SQUARES

Determinants	Commercial Paper		LIBOR		Eurodollar Deposits	
	1-Month	3-Month	1-Month	3-Month	1-Month	3-Month
Constant (t-Stat)	.0038 (2.977)	.0050 (4.009)	.0029 (1.342)	.0013 (0.565)	.0024 (1.048)	.0007 (0.297)
$\ln(1 + Tbill_{-1})$ (t-Stat)	.0337 (2.415)	-.0091 (-0.675)	.0515 (2.162)	.0501 (2.039)	.0321 (1.303)	.0323 (1.325)
$\ln(1 + Tnote_{-1})/(1 + Tbill_{-1})$ (t-Stat)	-.1014 (-3.460)	-.0122 (-0.428)	-.1807 (-3.610)	-.1199 (-2.324)	-.1988 (-3.837)	-.1357 (-2.647)
$\ln(1 + Inflation_{-1})$ (t-Stat)	.0149 (1.157)	.0126 (1.008)	.0464 (2.112)	.0841 (3.711)	.0600 (2.641)	.0914 (4.066)
$\ln(1 + Fedfunds\ volatility_{-1})$ (t-Stat)	-.0135 (-2.480)	-.0099 (-1.878)	.0246 (2.649)	.0322 (3.370)	.0297 (3.094)	.0394 (4.149)
<i>D1974Q3</i> (t-Stat)	.0129 (4.559)	.0067 (2.439)	.0214 (4.434)	.0234 (4.698)	.0209 (4.193)	.0242 (4.893)
<i>D1980Q4</i> (t-Stat)	.0047 (1.699)	-.0085 (-3.124)	.0119 (2.503)	.0049 (0.997)	.0117 (2.376)	.0056 (1.154)
Measures of Fit						
R-bar squared	.488	.132	.581	.598	.582	.621
Standard error (In basis points)	31	30	50	52	51	51
F(6,103)	18.30	3.76	26.24	28.03	26.34	30.70
Measures of Residual Randomness						
D.W.	1.12	1.14	0.78	0.85	0.78	0.80
Q(27)	86.3	79.6	124.8	94.1	99.1	87.8
First-Order Autocorrelation Coefficient	.439	.430	.565	.532	.565	.555

SOURCE: Congressional Budget Office.

NOTES: The dependent variable is $\ln\{(1 + Rate)/(1 + Tbill)\}$, where *Rate* = {commercial paper, LIBOR, Eurodollar}. The estimation interval extends from the second quarter of 1971 (1971Q2) to the third quarter of 1998 (1998Q3).

LIBOR = London interbank offer rate; D.W. = Durbin-Watson statistic.

TABLE A-2. CBO ESTIMATES OF SQUARED RESIDUALS USING THE ARCH MODEL

Determinants	Commercial Paper		LIBOR		Eurodollar Deposits	
	1-Month	3-Month	1-Month	3-Month	1-Month	3-Month
Constant (t-Stat)	-12.018 (-8.454)	-12.506 (-9.071)	-10.266 (-7.371)	-9.644 (-7.764)	-8.718 (-6.727)	-9.009 (-7.454)
$\ln(u^2_{t-1})$ (t-Stat)	.167 (1.762)	.149 (1.596)	.207 (2.168)	.295 (3.315)	.370 (4.174)	.343 (3.948)
$\ln(1 + \text{Inflation})$ (t-Stat)	21.485 (2.799)	22.825 (2.691)	8.545 (0.859)	22.208 (3.222)	18.758 (2.150)	21.218 (3.136)
Measures of Fit						
R-bar squared	.108	.076	.040	.216	.200	.242
Standard error (In basis points)	2.153	2.469	2.856	1.909	2.463	1.886
F (2,106)	7.54	5.47	3.225	15.87	14.48	18.26

SOURCE: Congressional Budget Office.

NOTES: The equation $\ln u_t^2 = \text{constant} + \alpha \ln u_{t-1}^2 + \beta \ln(1 + \text{Inflation}_t)$ was used to estimate the model. The estimation interval extends from the third quarter of 1971 (1971Q3) to the third quarter of 1998 (1998Q3).

ARCH = autoregressive-conditional heteroskedasticity; LIBOR = London interbank offer rate.

TABLE A-3. CBO ESTIMATES OF INTEREST RATE SPREADS USING GENERALIZED LEAST SQUARES

Determinants ^a	Commercial Paper		LIBOR		Eurodollar Deposits	
	1-Month	3-Month	1-Month	3-Month	1-Month	3-Month
Constant (t-Stat)	.0032 (3.919)	.0050 (5.857)	.0012 (0.754)	-.0001 (-0.107)	-.0001 (-0.739)	-.0006 (-0.521)
$\ln(1 + Tbill_{t-1})$ (t-Stat)	.0526 (4.574)	-.0016 (-0.147)	.0750 (3.625)	.0696 (3.653)	.0866 (5.691)	.0552 (2.998)
$\ln(1 + Tnote_{t-1})/(1 + Tbill_{t-1})$ (t-Stat)	-.0882 (-4.005)	-.0459 (-2.177)	-.1851 (-4.570)	-.1101 (-2.780)	-.1510 (-5.737)	-.1222 (-3.418)
$\ln(1 + Inflation_{t-1})$ (t-Stat)	.0058 (0.502)	.0055 (0.526)	.0637 (3.678)	.0644 (3.565)	.0394 (2.894)	.0704 (4.281)
$\ln(1 + Fedfunds\ volatility_{t-1})$ (t-Stat)	-.0166 (-3.507)	-.0077 (-1.910)	.0199 (2.371)	.0390 (4.639)	.0246 (3.146)	.0404 (4.915)
D1974Q3 (t-Stat)	.0135 (2.263)	.0062 (1.254)	.0200 (2.700)	.0244 (2.175)	.0228 (1.972)	.0258 (2.311)
D1980Q4 (t-Stat)	.0047 (1.072)	-.0084 (-1.972)	.0106 (1.712)	.0053 (0.683)	.0117 (1.414)	.0065 (0.865)
Measures of Fit						
R-bar squared	.491	.294	.799	.658	.808	.603
Standard error (In basis points)	31	31	52	52	51	52
Measures of Residual Randomness						
D.W.	1.09	0.99	1.08	1.00	0.96	0.96
Q(27)	49.4	90.1	130.8	116.3	114.5	100.9
First-Order Autocorrelation Coefficient	.442	.495	.426	.468	.463	.490

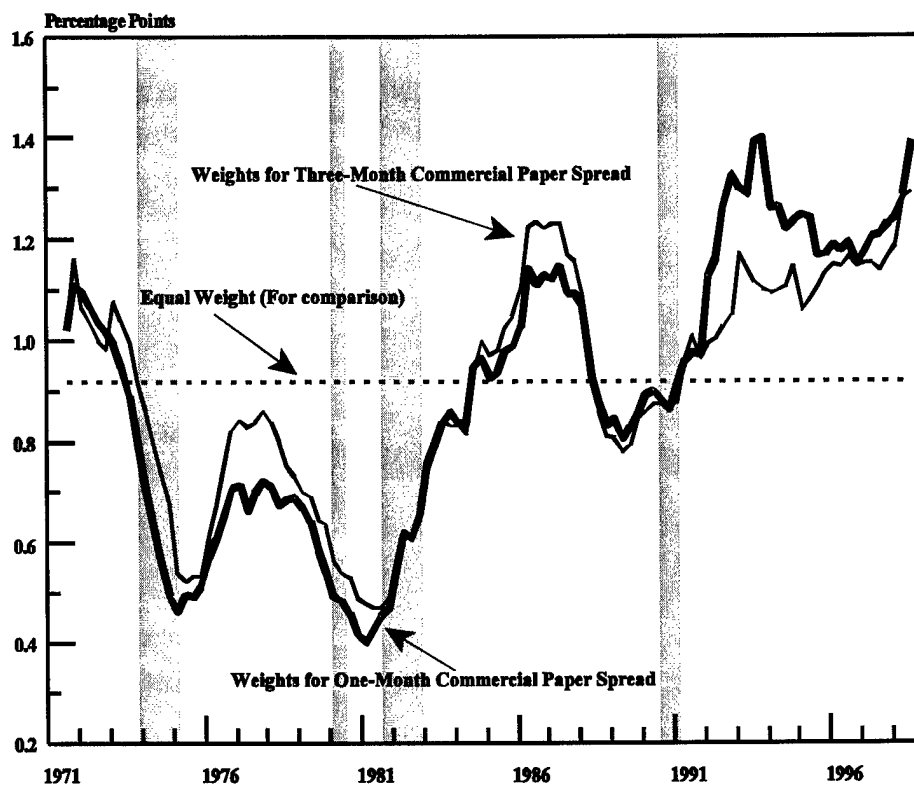
SOURCE: Congressional Budget Office.

NOTES: The dependent variable is $[\ln\{(1 + Rate)/(1 + Tbill)\}]/\sigma$, where σ is the square root of the fitted values from the ARCH model. The estimation interval is from the third quarter of 1971 (1971Q3) to the third quarter of 1998 (1998Q3).

ARCH = autoregressive-conditional heteroskedasticity; LIBOR = London interbank offer rate; D.W. = Durbin-Watson statistic.

a. The determinants are all divided by σ_e , the square root of the fitted values from the ARCH model.

FIGURE A-1. DATA WEIGHTS USED IN CBO'S MODEL FOR PROJECTING INTEREST RATE SPREADS FOR ONE-MONTH AND THREE-MONTH COMMERCIAL PAPER

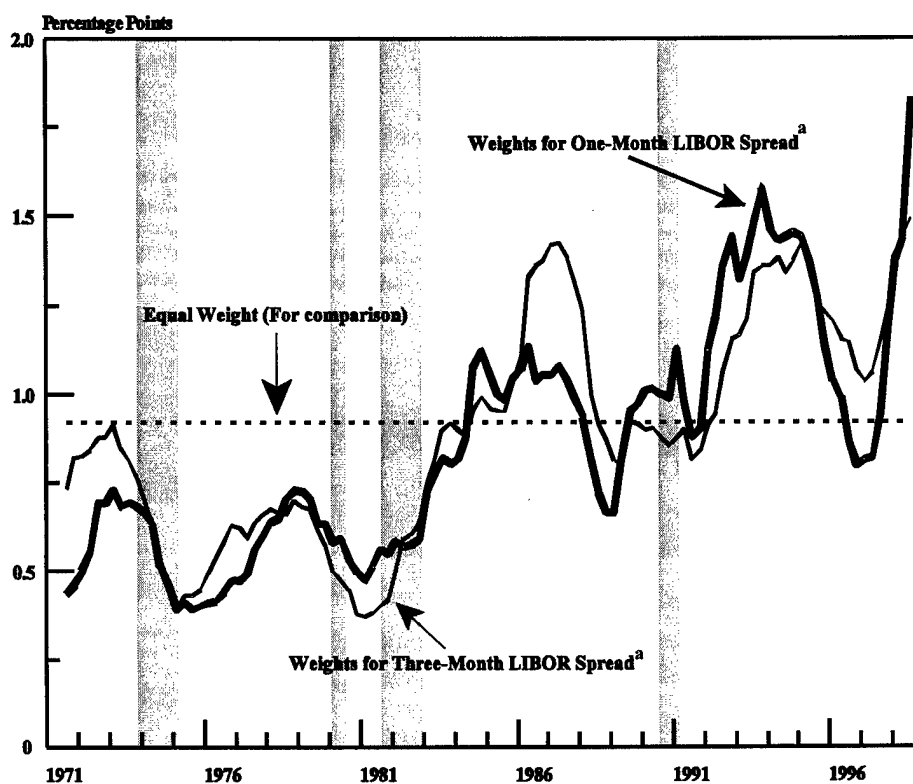


SOURCE: Congressional Budget Office.

NOTES: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

Commercial paper is defined here as short-term debt issued by financial companies.

FIGURE A-2. DATA WEIGHTS USED IN CBO'S MODEL FOR PROJECTING INTEREST RATE SPREADS FOR ONE-MONTH AND THREE-MONTH LONDON INTERBANK DOLLAR DEPOSITS



SOURCE: Congressional Budget Office.

NOTE: Spreads (the differences between rates) are computed against the rate for three-month Treasury bills. Interest rates have been converted to bond-equivalent yields.

a. The rate on London interbank dollar deposits is known as LIBOR—the London interbank offer rate.

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